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IRON and STEEL ENGINEER

FUEL — ELECTRICITY — MACHINERY — METHODS

EMPIRE BUILDING, PITTSBURGH, PA.

To Educate the Engineer in Industry

MARCH, 1924

Containing the Proceedings of the A.I.&S.E.E.

Steel Works Lighting

By D. W. BLAKESLEE

Electrical Engineer, Jones & Laughlin Steel Company, South Side Works, Pittsburgh, Pa.

General Phases of Pyrometry and Temperature Control in the Steel Industry

By O. BREWER

Engineer, Leeds & Northrup Company, Philadelphia, Pa.

Experiences with Multiple Feed, High Pressure Lubrication

By L. R. HUMPTON

Chief Electrical Engineer, Parksburg Iron Company, Parksburg, Pa.

The Economies of Electric Heat in Metallurgical Processes

By DWIGHT D. MILLER

Consulting Engineer, New York, N. Y.

A. I. & S. E. E. General Specifications for Construction and Installation of Automatic Engine Stops

Standardization of Engine Stops

By WALTER GREENWOOD

Safety Engineer, Ohio Works, Carnegie Steel Company, Youngstown, Ohio

Anti-Friction vs. Sleeve Bearings

By J. S. MURRAY

Electrical Engineer, Follansbee Brothers Company, Toronto, Ohio

Yearly Increase in the Use of Westinghouse Turbine-Generators

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Our engineers will gladly discuss these new features with those interested in power generation in the steel industry.

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IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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WILLIAM T. SNYDER

The Electrical Engineer Who First Proved the Possibilities of the Remote Control Sub-Station in the Steel Industry

Mr. Snyder associated himself with the National Tube Company in 1898, serving in various capacities in the electrical department until 1909, when he was made superintendent of this department.

In 1909 he was connected with the installation of a 3,000-kw. power station, the turbine being operated by the exhaust steam from the blooming and slabbing mill. One very interesting feature in connection with this installation is the 6,600-volt transmission line running along the harbor wall. This system is protected with all of the safety features known to human kind.

Always a pioneer and endowed with a remarkable sense of foresight, Mr. Snyder has been connected with many of the earlier applications which in later years were accepted as standard practice.

In 1916 Mr. Snyder designed and supervised the installation of the first remote control sub-station in the steel industry. A complete description of this sub-station may be found in the 1918 Proceedings, pages 479 to 484. This sub-station operated so successfully that in 1919 three more 1,500-kw. remote control sub-stations were installed, and these are also operating successfully.

In 1919 Mr. Snyder was the engineer in charge of the construction of a 10,000-kw. power plant, which embraced the excavation and foundations, the erection of buildings, the installation of the boiler plant and all its auxiliaries, a modern pumping station, a high pressure steam turbine, together with all the electrical apparatus in connection with a modern power plant.

Mr. Snyder's activities in the A. I. & S. E. E. began in 1911, when he acted as Chairman of the Revision of the Constitution Committee, and also presented a paper before the Association, title, "Crane Track Wheels." In 1912 he presented a paper, "Tubular Pole Construction." In 1913 he served as Chairman of the Editing Committee. In 1914 and 1915 he acted as Secretary of the Association. In 1916 he served as President, and in 1917 acted as Chairman of the Standardization Committee. During this year the A. I. & S. E. E. made their first real step towards standardization, and a review of the Yearly Proceedings of this year will be sufficient to indicate how well the chairman and his committee executed their responsibilities. One of the interesting features in the standardization report of that year was a tabulation showing the ratings and principal dimensions of popular sized motors. It indicated plainly that with the co-operation of the manufacturers outline dimensions at least could be standardized.

A veteran in the steel industry, a pioneer in the Association's activities, an earnest advocate of the advancement of the application of electricity to the iron and steel industry, a builder, an organizer, a man who believes in the development of the engineer for service.

EDITORIALS

THREE SCORE YEARS AND TODAY

Everywhere, on every hand, we see the rapid march of progress, and recently while visiting the Cambria Plant of the Bethlehem Steel Company at Johnstown, Pa., the deevlopments in steel making and processing were forcibly brought to mind by one of the pioneer steel converters, which is located in the offices of this company.

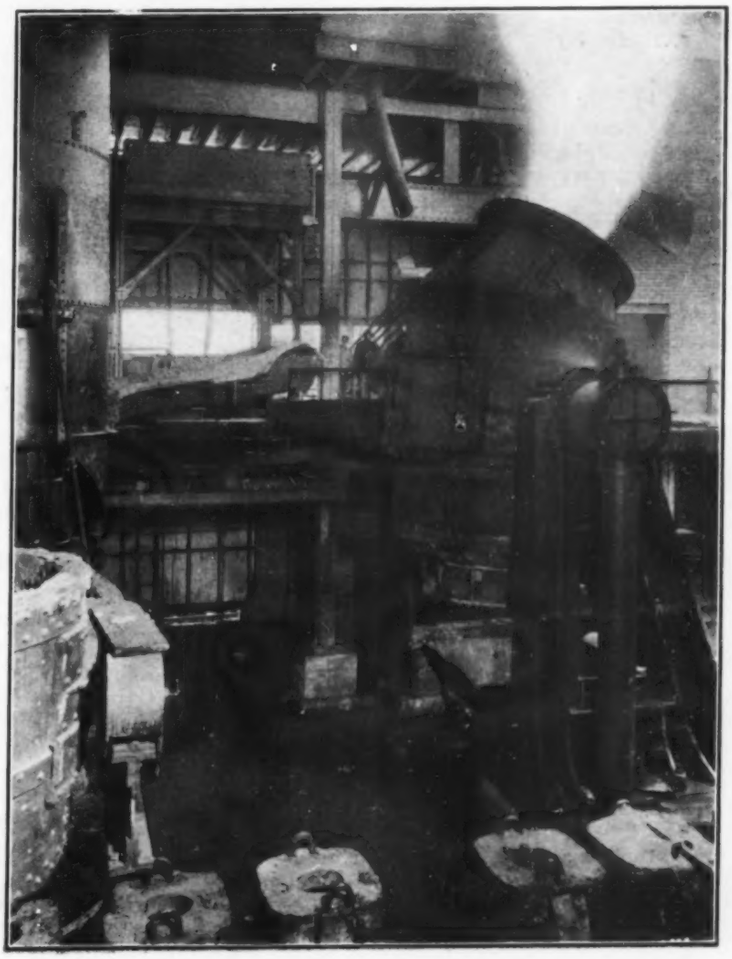
In an interview with Mr. D. M. Stackhouse, of the Bethlehem Steel Company, we learned that this converter is a most interesting historical metallurgical relic ,one of Wm. Kelly's early steel converters, in which he made steel at the Cambria Iron Company's plant in 1857.

A pictorial contrast is presented to show the advancement in the art of steel making. One picture represents one of the earliest converters, the other picture illustrates the most modern converters in use today.

In 1851 William Kelly, who then operated a small iron works at Eddyville, Ky., conceived the idea that if air was blown through liquid pig iron, the impurities would burn out, leaving pure iron. This idea was brought about through Kelly's observations at a puddling furnace. In watching the charge in the furnace he noted that the cold air, which was drawn into the furnace through natural draft, heated the sides of the puddle ball, which on the contrary seemed to him, should cool the charge. He became interested in this phenomena and through his experiments developed the method of forcing air through hot metal to purify it. Kelly named his method the Pneumatic Process. About the same time Henry Bessemer was conducting similar experiments and arrived at the same conclusion which resulted in the Bessemer Process.

Further researches by both Kelly and Bessemer proved that their theories were correct, that manganese, silicon, and carbon would oxidize under both processes, and that the iron itself would not burn unless subjected to a continual blow. The theories advanced by both men also proved that in the oxidation of these elements sufficient heat was developed to keep the metal fluid, and purify it without the addition of any other fuel. This is one of the advantages of this process over the open hearth practice.

Wm. Kelly and Henry Bessemer made quite a number of these converters, the earlier ones being stationary, the blast being blown through the sides. Some of Kelly's earlier experiments were witnessed by the late James H. Geer, a native of Johnstown. In relating his experiments he said that the pig metal was first reduced in a foundry cupola. About 300 lbs. of hot metal constituted a charge, and a foundry ladle carried by hand was used for transporting the hot metal from the cupola to the converter. In one of the first trials, the pressure used in blowing the air through the con-



verter, was so strong, that it blew the liquid pig iron out of the converter. On the next trial however, the blast pressure was reduced and the process resulted successfully, a heat of steel being produced. The steel was again poured into a foundry ladle, and then into rectangular molds 3 in. wide by 4 ft. long.

Tests of the steel were made in the company blacksmith shop, and while no record exists of the actual results of these tests, there is no doubt that the steel cracked when worked hot. No method existed at that time for the elimination of red shortness in steel, Henry Bessemer's early trials were also failures, due to the same causes. Later when Henry Mushet discovered that if manganese was added to the bath after the heat was blown, the red shortness disappeared, and then this process of Kelly's and Bessemer's became a commercial success.

It seems that Kelly's efforts were confined to invention only, as he demonstrated his lack of business foresight by neglecting to take advantage of the patent laws of the United States, and it was not until after Henry Bessemer made an application for the patent rights of America did Kelly make any effort to commercialize his activities. He was granted a patent over Henry Bessemer on the grounds of priority of invention.

The result of this invention was immediately apparent, inasmuch as more uses for steel were immediately found, and the consumption of steel per capita in this country increased far beyond the comprehension and dreams of the men in the industry at that day.

William Kelly was born in 1811 and died in 1888. He accumulated a small fortune from the royalties which accrued from the use of the Kelly Pneumatic Process.

THE INSULATION PROBLEM

At a meeting held under the auspices of the Philadelphia Section of the A. I. & S. E. E., Mr. C. E. Skinner presented a most interesting and practical discussion on the "Development of the Insulation Art," which began with the introduction of dielectric or breakdown testing. Little was known of the breakdown values prior to 1890 when insulation was tested by ringing out with a magneto or by measuring the insulation resistance.

Today, we have a million volt transformer which explains in a sentence the progress made in insulation testing.

In his paper the author divided his subject into six major headings: Historical; Insulating Materials and Their Character and Limitations; Insulation Testing; Manufacturing Processes; Insulation Research and Insulation of Steel Mill Electrical Machinery.

The paper prompted considerable discussion from the steel mill engineers. One engineer advanced the theory that the insulation problem was the only factor which would prevent a 15,000 h.p. motor from operating 50 years, provided a method could be evolved for the cleaning of this motor to prevent dirt and dust and oil from ruining the insulation.

Many questions were raised as to the relative values of various materials for insulating purposes, the effect of different grades of oil for use in transformers, etc. Many of the engineers offered the opinion that if some oil resisting insulation was found, d.c. motor troubles would rapidly disappear. Methods of cleaning and inspection of electrical machinery were discussed and a number of successful systems were described.

One engineer complained of the method of insullating form wound coils for armatures as it is necessary to tear down a complete armature on account of the manner in which coils are baked into the armature slots. A method for cleaning was advanced. washing the windings with gasoline and air, later painting with air drying varnish.

Tetra carbon chloride was recommended as a cleaner by an engineer who claims the practice was successful.

This paper together with the complete discussion will appear in the Iron and Steel Engineer in an early issue. Watch for it.

FUEL SAVING

Did you ever stop to realize the enormous losses in fuel in the average steel plant, due to the inefficient small steam driven units with their endless maze of small steam lines? Was ever a real attempt made to estimate the tremendous losses through two small sources alone, namely, steam radiators and siphons?

We quote figures which, if used to total the aggregate losses going on in the plants, would quickly command action from the executives of our great industry.

Steam Loss Through Radiators and Siphons.

RADIATORS

Eight pipes 2 in. diameter, extra heavy, 20 ft. long.
Surface—100 sq. ft.
Steam Temperature — 150 - 366 deg. F.
Room Temperature — 70 deg. F.
Heat Loss — 96,000 B.t.u.
B.H.P. Loss — 3.50 B.H.P.

SIPHONS

Siphon Size	Nozzle Size	B. H. P.
2½"	9/16"	49.9
3"	5/8"	61.2
4"	11/16"	74.6
6"	1"	157.8

ELECTRIC DRIVEN REVERSING ROLLING MILLS

Saturday, April 19th, 1924, the Pittsburgh Section will convene for an all-day session, at which time a paper covering the subject of Electric Driven Reversing Rolling Mills will be presented for the engineers of the steel industry.

This joint paper will be compiled by the electrical companies who build this apparatus and it will be a purely engineering discussion.

The paper, together with the complete discussion will appear in the Iron and Steel Engineer and will be distributed to the entire steel industry and to those engineers who are interested in this subject. Every effort will be made to make this article so complete that it will become the recognized standard reference when electric driven reversing rolling mills are discussed preparatory to purchase.

Headquarters for the day, April 19th, 1924, will be in the Blue Room of the William Penn Hotel, Pittsburgh, Pa.

A. I. & S. E. E. Iron and Steel Cost and Practice Chart

By B. R. SHOVER*

The idea of publishing a chart showing costs and practice was suggested by Mr. John F. Kelly, business manager of the Association, at whose request the writer consented to undertake its compilation.

Although there are few, if any, such plants in existence, a balanced installation was assumed in order to define the scope of the work, and also to indicate relative values.

In estimating "Cost of Installation," the attempt was made to assume average construction and not take either the most expensive or the cheapest.

Practice, as represented by figures for "Raw Materials" and "Products," are the closest even figures to the true or weighted averages of tonnages running into the millions, and the figures on the charts are believed to be representative of average conditions as regards different plants, variations in the character of raw materials, etc.

Obviously the greatest problem was "Costs," for while a large amount of data collected over a period of years was available, hardly any two concerns use the same captions on their cost sheets, and even if such is the case, comparison showed a great difference in the interpretation of those captions as to what items of cost should be included. In many cases certain figures were so far off from the average that they had to be neglected.

The basis of the cost figures in each column is the curves shown at the top. These were made by changing the available costs to correspond with a plant of the size assumed, and the figures finally accepted represent the combined judgment and experience of several engineers and steel experts. The costs were then spotted on cross section paper at points corresponding to the labor rates prevailing for their different years, and while the resulting "target" greatly resembled the effect of a charge of bird shot, there was still a definite direction, and by averaging the costs in different labor rate zones, points were secured from which the shape and direction of the curves could be produced.

It will be noted that in every instance except Coke Ovens, "All Other Costs" go up with the increase of common labor rates more rapidly than "Department Labor," which can only be explained by extra profits being taken by concerns furnishing materials used in repairs, etc. This was very noticeable when an attempt was made to check the curves from figures obtained, after the labor rate was reduced, when the drop in "Department Labor" was very much more rapid than in "All Other Costs," and it is to be regretted that sufficient data was not available to show this effect.

As previously stated, there was considerable difference in the itemized costs of the various plants, but this difference was marked less for "Total Cost Above," and while different plant layouts and equipment would account for some of the discrepancies, methods of cost accounting are probably responsible for more. The divisions given on the chart were obtained by reducing all itemized costs to a 40c base in proportion to the curves, and then averaging these results.

This chart is believed to be the first of its kind and should it prove useful, it should be revised from time to time in order to be of value, and with this end in view the Association would welcome criticisms of this issue and suggestions for possible future editions.

*Consulting Engineer, Pittsburgh, Pa.

New Slide Rule Simplifies Design Work

Whenever in any given line of manufacture it is necessary to make a considerable range of sizes of articles, the work of preparing drawings in which such items appear is made irksome by the necessity of referring to rather complicated tables and diagrams by which the standard dimensions of the whole series of articles are shown. In preparing detail and assembly drawings from such diagrams and tables, mistakes are frequently made, either by taking values from the wrong column or line of the table, or by selecting the wrong reference letter in the diagram.

The American Engineering Standards Committee has called attention to a newly developed slide rule for standards parts, which was recently put on the market in Switzerland and was exhibited at the international standardization conference at Zurich. In the use of this novel aid to the draftsman and designer, the danger of making mistakes in transferring standard dimensions to drawings and computations is practically eliminated; and, furthermore, it is used much more quickly and conveniently than the usual tables of standard parts.

The slide rule presents all essential dimensions for the full series of the Swiss standard bolts, nuts and washers, so that by moving the slide to such position that the desired diameter appears through a window or opening in the fixed part of the rule, all the dimensions for the other parts of the bolt of that size appear in the corresponding rectangles on a clear diagram of the bolt which is engraved on the fixed part of the rule. In this way, each dimension appears in exactly the place where it applies. For example, the diameter of the washer appears just where the washer would be dimensioned in any actual drawing incorporating the bolt, nut and washer combination.

In addition to the fundamental dimensions of the bolt itself, the rule provides a convenient means of showing also the diameter of the drill that is to be used for drilling a threaded hole to receive the bolt; the diameter of the cotter pin to be used; the effective cross sectional area of the bolt in square inches; its safe carrying capacity in pounds; and the working stress at that load in pounds per square inch.

The same slide rule carries on the reverse side a similar presentation of the dimensions of two other standard design components, shaft keys and gas pipes. This rule illustrates one of the advantages of standardization in favoring manufacturing economy. It is adapted to all cases where standard dimensions have been determined upon for parts, components or complete machines.

A reprint giving a picture and detailed description of this slide rule is available upon request to the American Engineering Standards Committee, 29 West Thirty-ninth Street, New York City, at whose offices samples of the rule may be seen.

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Steel Works Lighting

By D. W. BLAKESLEE*

THE steel and iron industry leads in connected horsepower of motors; also, if not first, it is pretty near the top in current consumption for lighting. Some individual works spend as much as $20,000 per year for lamps alone, and $40,000 for energy for illumination, but there is a greater proportional return on the money spent for illumination than for any other thing. A dollar now buys 16 times the illumination it did in 1888. During the past 10 years it may be said that the increase in return is about 62 per cent. The design, installation and maintenance of the lighting systems in a steel and iron works may be seen to be of no little importance. Beside the furnace and mill applications, there are many others such as machine shop, carpenter shop, pattern shop, foundries, repair shops, roll turning shop, water works, power plants, laboratories, storage buildings, yards, drafting rooms, and other office applications.

Safety Insurance.

Of 500,000 industrial accidents in one year, 25 per cent were directly due to inadequate illumination. Lighting in most steel works applications is primarily for the sake of safety. Those applications where the illumination is for the increase in efficiency of visual operations may be said to be auxiliary activities; they are repair shops, drafting rooms, offices, etc. Although the former is of more importance, the latter may be of more interest as an engineering application of illumination.

The increase in the hours of darkness in the winter increases the number of industrial accidents. During December and January the number of industrial accidents is more than double the number in June and July. Proper lighting not only prevents accidents, but it also promotes good health. Many states now have lighting codes which give requirements and recommendations. They are in the main based on the recommendations of the Illuminating Engineering Society.

Although the lower intensities are used in most of the code classifications, it is in the applications which fall within these classifications that lighting is done for the sake of preventing personal injury to the body of the workman.

More illumination is required in toilets, washrooms, etc., where it is important that everything be kept clean. Here lights also promote sanitation and good health. It is only in the applications calling for still more illumination that there is danger of the introduction of glare. Glare, which has been called "light out of place," may produce a greater detrimental effect than not enough illumination. There are many conditions which produce glare or the effect of glare, and these conditions must be avoided to prevent injury to the eye and a reduction of the efficiency of the employe. The lighting must be such that no lamp filaments of great brightness come within the range of vision, bright lights must not be reflected into the eye, contrast of low and high illumination must be avoided, and flicker effect of any sort must be prevented.

Good Investment.

Better illumination is not only important in industrial applications because of the reduction of many of the hazards to life and limb, and because of its beneficial psychological effect, but because it is a paying investment otherwise. This has been proven in actual applications many times. In some the output has been increased 12½ per cent by an increased lighting expense of 2½ per cent of the payroll. This explains why industrial organizations are willing to invest what might otherwise seem so much money for lighting material and to employ illuminating engineering talent.

Wiring Systems in Use.

In many steel works 25-cycle current has been used for lighting as the alternating current of that frequency was employed for power applications and it was more economical for distribution than continuous current. But 25-cycle is not satisfactory for lighting offices or other places where eye strain is liable to develop due to the flicker.

As 60-cycle current has all the advantages as to transmission and does not have the disadvantage of producing flicker, it is now largely used for lighting circuits, especially for offices. It is even worth the investment to install motor-generator sets to obtain this current if there is no other 60-cycle power plant equipment. In the installation of a 60-cycle lighting system it would be advantageous to have the potential of the low side of the distribution transformers produce 115 volts at the lamps instead of 110 volts as has been the custom in the past. This is to permit the standardization of lamps.

Direct current is used in almost all buildings and yards in a steel works for cranes and other power equipment so that current is always available for lighting. Voltage fluctuations due to local changes in the load produce some variations in the intensity of the illumination, but as a low order of illumination is required in applications where this source of current is used for lighting the variation is not objectionable.

As 230-volt lamps do not have as great an output in lumens as do the 115-volt lamps for a given rating in watts, more light is obtained by using 115-volt lamps two in series in across the 230-volt branch. The disadvantage of this arrangement is that when one lamp is broken two go out. Both lamps must then be changed; two new ones put in, and the good old one used with another one which has been burned about the same length of time.

Lamps Used.

It is of course desirable to keep the number of differently rated lamps used in a works down to a minimum in order to save storage space, to permit the purchase of larger quantity of each lamp, and to reduce the possibility of using the wrong lamp. In a works having 110 volt a.c. office lighting and 230 volt d.c. circuits across which 230-volt lamps and 115-volt

*Electrical Engineer, Jones & Laughlin Steel Corporation. Member A. I. E. E., Illuminating Engineering Society, Association of Iron and Steel Electrical Engineers, etc.

lamps two in series, are operated, the following are recommended for stock sizes:

110 volt—40, 60, 100, 400 watts.
115 volt—25, 100, 200, 400, 500, 750 watts.
230 volt—50 (mill-type), 100, 200, 300, 500, 1,000 watts.

Hand and pocket flash lights are carried for use of foremen, inspectors, etc. These are of both two and three cell type.

The lamps purchased should be of the best obtainable. They should be received so packed as to produce a minimum of labor, space and breakage in placing in supply storage and dispensing for use. The average cost per lamp runs about $1.00. About half as many lamps are used for safety and signals as are used for illumination; the average cost of these lamps runs about 21 cents.

Mill Type Lamps.

Where lamps are subject to shocks such as on extension cords, on cranes, etc., the mill-type lamps should be used. The mill-type lamp is so constructed that the filament is harder to break. It is therefore a better investment than the standard Mazda B lamp. But in substituting the mill-type lamp in guards or reflectors a standard 1⅜-in. socket extension or adapter should be used. It should be used in most wire guards because the change in the shape of the bulb may cause it to come in contact with the guard, but it is more important that it be used in the reflectors because of the change in the relative position of the filament.

Schedule of Relative Illumination Values for Applications:

(a) Roads
Yards
(b) Boiler houses
Bessemer converters*
Mixers*
Stock buildings*
Open hearth shops*
Strippers*
Storage buildings†
(c) Gas producers*
Power houses
Rolling mills
Rail and bar sheds
Locomotive house
Bolt and spike factory
(d) Structural shops
Foundries
Forge and hammer shops
Polishing mills
Machine shops‡
Carpenter shop‡
Pattern shop‡
Electric shops‡
Offices§

*For safety on walkways, etc.
†Higher where steam is present, as over acid pickle baths.
‡General or local up to 10 and 25 foot candles in some applications.
§15 foot-candles for drafting work.

Possible average value of foot candles are:

a	½
b	1
c	2
d	3

Productive Illumination.

The term productive illumination has been used to designate that illumination at and above which the eye reaches its practical limit of sensitiveness. This point is reached when the intensity of the light which enters the eye is of the order of two foot-candles. As most surfaces in the mills and shops in a steel and iron works are poor reflectors, the intensity incident on the work planes must be of values much above two foot-candles, depending upon the color and finish of those surfaces and upon what should be seen in connection with the work. In most lighting applications in a steel mill it has not been thought necessary to have the eye up to the limit of productive sensitivity. Therefore the intensity of illumination on dark surfaces need not always be greater than that on light surfaces under observation; for instance, the illumination of the work in a forge shop need not be as great as that in a drafting room. But on the other hand, more light is needed on the steel while inspecting billets or cold rolled products than is required for general office work.

Lights Not for Illumination.

There are many lamps used in steel and iron works for signal and safety applications. In the successful operations of furnaces and mills much depends upon the continuity of flow of material between the points of the various operations. White and colored lamps are located at these points as required and switches provided so as to operate the lamps at the points above and below in sequence of material flow. Other signal lamps are for railroad crossings and switches, fire alarms, and telephone calls.

There are perhaps more lamps used for "safety" than those for signals as mentioned above. These include railroad no-clearance signs, stretcher stations, bulletin boards, fire exits, and police.

Rated Voltage.

In the purchasing of lamps the specifications should not be left to the purchasing agent, who may give the requirement as "110 to 125 volts." The lumen output can only be obtained when the lamp is across its rated voltage. Therefore it should be purchased for 110, 115 or 120 volts, as may be required. The output of a 125-volt lamp on 115-volt circuit may be about 75 per cent of its rated lumens. Price and delivery may also depend to some small extent on the voltage rating. Of the incandescent lamps purchased in the United States in 1922 about 25 per cent were 110 volts, 40 per cent 115 volts, 25 per cent 120 volts, and 5 per cent 125 volts.

Life of Lamps.

Once in every few years some get the idea that the new lamps are of short life. There will never again be any trouble with short life lamps. The averages of tests made indicate that if anything the lamps may be used too long. Results from some stock lamps in actual steel mill lighting may be indicated by the following: Per cent of lamps burning at the end of 1,800 hours operation—100 for 200-watt, 125 and 250 volts; 70 for 300-watt, 250 volt; 60 for 400-watt, 125 volt.

At the end of one and a half rated lifetime the type "C" lamps drop to less than 90 per cent and the type "B" to about 75 per cent of the rated lumens output. To obtain efficient illumination lamps which burn 24 hours a day should be changed at intervals not longer than two and three months for types "B" and "C,"

respectively. The lamps which burn less than 24 hours a day may be used for proportionately longer periods. The man whose duty it is to clean and maintain the lamps should keep a record of the renewals, the location of the outlets, and the dates.

Loss of Lamps.

In the lighting of steel works there may be a very great loss of lamps due to careless handling of lamps, resulting in theft and in breakage. As much as 7 per cent of the money spent per year for lamps has been known to be lost due to this cause. Old systems of local lighting should be replaced by the more efficient lighting systems by general illumination from large lamps which are hung out of reach. Where local lights are needed for internal machining, etc., an individual fused branch to the lamp on the machine tool may be run from the power side of the safety switch for the motor geared to the machine.

Many extension lamps are used by steel works tradesmen such as bricklayers and pipe fitters. These portable lamps and also their plugs, cords, and shades or reflectors, and guards are a very large part of the loss. This equipment should be given out on tool check for return. Much lighting equipment is lost through carelessness. It has been found a number of times bricked in the checker work during the rebuilding of open hearth furnaces; pipe trenches have been refilled with lamps still burning in their reflectors; box cars are frequently closed and hauled away with the extension cord hanging out, pulled from its receptacle.

In places such as brick sheds and room for the storage of other materials which may reach the light fixtures the reflectors should be equipped with wire guards to prevent anything from coming in contact with the lamps and thus breaking them. Everything possible should be done to prevent careless handling of lamps as the loss due to this cause has been known to run as high as about $3,000 per year in one large steel and iron works.

Types of Reflectors.

- Direct—
  - Porcelain Enamel
    - RLM dome
    - Deep bowl
    - Angle type
  - Glass
    - One-piece opal
    - Prismatic
  - Glass-Enclosing
    - One-piece opal
  - Glass-Semi-Enclosing
    - Metal reflector
    - Composition reflector
- Semi-Indirect—
  - Clear top enclosed
- Indirect—
  - Mirrored glass
- Projectors—
  - Mirrored reflectors
- Special

The above types of reflectors have been used in iron and steel works applications by the author. The one first in the list is of course the most used. But the advantages to be gained by the employment of the other types are sufficient for their selection for specific applications. The glass reflectors have been used almost exclusively in offices. With the type of men upon whom falls the duty of cleaning lighting equipment in the mill and furnace applications the glass reflectors would have a very short life, it is believed.

Projectors have been used with some little success, but they are difficult to maintain, and most steel works applications can be better made with some other type of reflectors. The most trouble with the projector has been the destruction of the reflector due to the heat of the lamp. To prevent glare the projector has to be mounted high, and due to space restrictions it usually has to be tilted to an elevation so much below the horizontal that the reflector comes over the lamp. The result is that the backing of the mirror peels off and some times the glass is broken.

Within the past few years the reflector and lamp manufacturers have been co-operating more closely to the end that there is available for industrial illumination, equipment which has been designed to form scientific combinations for the production and direction of light so that it may be used to the greatest advantage. The reflectors which conform to RLM standards are so labeled by the Electrical Testing Laboratory. As indicated in this paper, other forms of reflectors are desirable for some applictions, but when the RLM reflector is wanted it is important to see that it has the RLM label affixed, as at times substitutes not passed by the Testing Laboratory are sold as RLM reflectors.

Selection and Standardization of Reflectors.

It is desirable for any user of a great many lamps and reflectors to have available for use a good portable photometer. For best results the photometer should be one such as the Sharp-Millar with which measurements may be made of candlepower, illumination and brightness. In the past it has been worth while to have a dark room where experiments can be made. Before the time when the RLM dome reflector was standardized and labeled, it was with few exceptions, impossible to get usable candlepower curves for reflector manufacturers which would be comparable. There is still some variation in the intensity distribution of the many makes of RLM reflectors. It is believed, however, that as far as the illumination is concerned one make is about as good as another.

With reflectors other than RLM dome, tests of the reflectors being considered should be made by a photometer in a dark room for obtaining candlepower curve. From these curves brightness values may be calculated for the zones which may produce glare effect. These zones are between the angles of 65 and 90 deg. from the vertical. Illumination and glare tests should be made after the lighting units are installed where they are to be used. There are so many variable factors affecting illumination and glare that it is not worth while for an industrial user to make any dark room tests except candlepower.

If a photometer may not be kept available a substitute for indicating illumination intensity is the foot-candle meter which may be purchased at a relatively low price. It is of course not as accurate as the photometer, which is a scientific instrument, but the foot-candle meter is a useful tool for checking the condition or results of a lighting system.

In RLM reflectors the great differences are mechanical. The advantages and disadvantages are brought out most forcibly by trial use of each design considered for certain applications. The quality of the enamel on the reflector is about as important as the small variation in the RLM shape of the reflector as furnished by the different manufacturers, but as hinted above, the other material and the mechanical design should receive much consideration. Most of the trouble in steel works is with the breakage and burning of the porcelain sockets and their conducting parts. The socket should be very sturdy in design, glazed all over and with no cracks to admit moisture. The current carrying parts should be heavy and the contact for the center of the lamp base should be of material which will not lose its quality as a spring.

As the industrial reflectors receive very hard usage in many of the steel works applications they should be so designed that shocks and blows they may receive will not cause them to come apart some place. For the same reason their internal and external supports should be as strong as possible.

The reflectors should be so designed as to take up the least storage space in the supply room, and at the same time they should be so designed and constructed as to have the least number of parts which may be lost, and also so that the minimum time may be spent in wiring and installing them.

The temperature of the socket in the reflector is of some importance. The heat is dissipated in different ways in the various makes of reflectors: by conduction, by convection, and by radiation. Some reflectors are ventilated and some are not, either may have hot or comparatively cool sockets and lamp bases. It is believed that a non-ventilated reflector which has a relatively low temperature has the advantage as it may be stronger and more weatherproof and dirtproof. Because of the great advances made in the art and science of lamp construction, heating may affect the lamps but little.

Importance of Cleaning.

If lamps and reflectors are not cleaned the time soon comes when it costs less to pay for the cleaning than it does to pay for the current which produces no useful illumination. In some mills the cleaning has been neglected until but half of the obtainable illumination was secured. Such a condition in a large steel works might mean a waste of about $20,000 per year. The cost of keeping a lighting equipment clean in the same works would be but a small fraction of this amount. As it is with the enameled steel industrial reflector, so it is with other reflectors. To illustrate the importance of keeping glass, semi-enclosing, composition reflector, direct lighting fixtures clean, photometric measurements were made on the 22 desk tops lighted by a system of the above described luminaries the design of which is not available. Before cleaning the average illumination was 3.6 foot-candles; maximum, 4.0 foot-candles; minimum, 2.3 foot-candles. After cleaning, average, 6.8 foot-candles; maximum and minimum, 8.7 and 3.8 foot-candles, respectively. A private office lighted by the same reflector received desk top illumination before and after cleaning the unit of 1.65 and 4.4 foot-candles, respectively.

Importance of Painting.

The illumination of a building depends largely upon its interior painting. The following tests will give the best possible proof. An air compressor room built of structural steel and corrugated sheet iron is lighted by Mazda C lamps in RLM dome reflectors, and a few small windows. It was painted with aluminum paint. By photometer tests this painting made an increase in illumination of 300 per cent. The private office mentioned in the paragraph above was not painted for five years. It was painted again with the same white paint. The increase in illumination by daylight on the desk top was 500 per cent. The increase by electric light was 300 per cent.

General and Local Illumination.

There can be no doubt that general illumination is better in all industrial applications where daylight would be the best illumination. The claim has been made that the eye can be forced to function under the unnatural strain with direct illumination at half the required illumination from an indirect lighting system. This is because the direct lighting is more localized and the eye becomes dilated because of the larger areas of still lower intensity which fall within the field of vision. The eye working day after day under such conditions will be injured by glare effect although there will be no realization of glare. Therefore it is better that local lighting should not be used on drafting boards, over desks, or over benches or machines where work is done on the outer surfaces of materials.

There are certain applications where local lighting is necessary. In shops and foundries where work is to be done on the internal surfaces where the light from the general lighting system cannot penetrate to a sufficient extent, some sort of a good, sturdy, adjustable bracket, with a small Mazda B lamp with a suitable shade should be used. There are also a few special applications which cannot be made by standard means. One such application peculiar to steel works is that of roll turning where the rolls are placed in the lathes one roll above another and the roll turner gauges his work between the rolls. The roll shop in one of the largest steel works has just had its lathes equipped with special reflectors of painted sheet iron which direct between the rolls toward the turner the light received from local lamps enclosed in half reflectors in wire lamp guards. This method of local illumination used in conjunction with the system of general lighting gives the roll turners better illumination and does away with the fire hazard of the old time arrangement by the turners of newspapers hung up behind the rolls to reduce the glare from the old unshaded local lamps.

Cost Daylight vs. Cost Electric Lights.

In designing new steel works buildings for use as rolling mills, foundries, power houses or whatever, the cost of windows and skylights together with their cleaning and maintenance should be weighed against half the cost of energy for a satisfactory lighting system together with half its maintenance.

It will be seen that in some applications it is more desirable not to rely upon daylight illumination. It has been found for some buildings having windows that it is more advisable to operate the electric lights in the daytime than it is to try to keep the windows clean. This is true in dust and smoky applications.

Vapor Proof Fixtures and Fittings.

To reduce to a minimum the fire hazards due to explosion in coal crushing and conveying plants, in by-product chemical plants, oil houses, etc., the light-

ing conductors, switches, lamps are all enclosed in conduit systems which include vapor-proof or marine fittings and fixtures. The object is of course to keep any explosive mixture of air and dust, gas or vapor from being exploded by an accidental arc or the breaking of a lamp bulb.

Cut-Out Hangers.

To avoid accident hazard and to promote rapidity and ease of cleaning industrial porcelain enamel reflectors and the lamps within them, the reflectors may be suspended from cut-out hangers. These make cleaning safe in two ways: The unit is lowered where it may be cleaned without climbing a ladder; it is disconnected from the electrical circuit. A better and quicker job of cleaning may be done as the lamp is brought to the cleaning equipment instead of it being necessary to carry one handful of relatively ineffective cleaning material up to a hazardous position where the job will be slighted also because of the discomfort of the workman.

Safety Switches.

All lighting circuits should be controlled by enclosed switches or dead face panel boards. The practice in modern steel works is to employ for no purpose whatever any open knife switches where they may be within reach of other than electrician. The open knife switch, beside presenting the danger of electrical shock, is a fire hazard and permits the employe to get burned either while operating the switch in the course of his duty, or by his breaking the rules and lighting his cigarette at the arc formed by slightly opening the switch.

Opal Lamp Caps.

In some applications where RLM dome reflectors are used there is glare due to specular reflection from polished or glazed surfaces. Such is the case in the places where polished cold rolled or drawn steel is inspected, or on layout benches in the tinshop. This trouble has been in the past overcome by the application of opal lamp caps which fit around the lower part of the Mazda C lamp, thus preventing a reflected view of the high intensity filament. Now that the lamp manufacturers are able to put a satisfactory enamel on the tips of the lamps used for such applications presents many advantages.

Notes on Designs and Results.

Warehouse Office—

Illumination desired—8 foot-candles.
Type of reflector—Direct, glass semi-enclosing, metal reflector.
Coefficient of utilization—0.50.
Typical area—18x34 ft.
Flux required—4896 lumens.
Output of lamps—9793 lumens.
Output per lamp—1225 lumens.
Size of lamp—100-watt, 110-volt, Mazda C (1260 lumens).

After four months' use and two months after the equipment has been cleaned, the average illumination from 28 test stations was 4.5 foot-candles. Here the cleaning interval should not be longer than three weeks. The illumination was without glare and without shadows.

Planning Office, Machine Shop—

Illumination desired—6 to 10 foot-candles.
Size of room—30x65 ft.
Ceiling height—8 ft. 6 in. (Midfloor between first and second floors.)
Type of fixture—Glass enclosing, one-piece opal, flattened top, direct.
Depreciation factor—1.5.
Coefficient of utilization—0.34.
Number of outlets—28. (Determined by beams across ceiling.)
Output per outlet—3100 lumens (200-watt, 115-volt lamp.)

After being used three years and having gone through a bad fire, this system by photometer measurement is now giving an average of 6.5 foot-candles with 125-volt lamps across 120-volt potential.

Drafting Room—

Illumination desired—15 foot-candles.
Typical area—56x88 ft.
Ceiling height—15 ft. 6 in.
Type of reflector—Indirect, mirrored reflector.
Room index—4.
Coefficient of utilization—0.28.
Effective light—74,000 lumens.
Total output—265,000 lumens.
Outlets spaced—10x12 ft.
Number of outlets—45.
Outet per lamp—5900 lumens.
Size of lamp—400-watt (6700 lumens).

This drafting room had not been painted for more than five years. Photometer measurements at 30 test stations so chosen as to give an average result produced an average illumination of 7.25 foot-candles on the working plane. After the ceiling and upper walls had been painted a light cream and the lower walls a buff, measurements at the same test stations gave an average illumination of 15.5 foot-candles.

Coming Meetings of A. I. & S. E. E.

Pittsburgh, April 2 and 3, 1924—

Fuel Savings Conference. Inspection trips. (See page 140 for complete program.)

Philadelphia, April 5, 1924—

General Ideas and Discussions. Every active member is invited to prepare a short paper on a subject pertaining to the application of electricity to the iron and steel industry.

Cleveland, April 12, 1924—

"Automatic Substations," by C. Lichtenberg, Engineer, General Electric Company, Schenectady, New York.

Chicago, April 18, 1924—

"Large Power Stations of the Commonwealth Edison Company," by B. G. Jamieson, Engineer, Commonwealth Edison Company, Chicago, Ill.

Pittsburgh, April 19th, 1924—

"Electric Driven Reversing Rolling Mills," by J. D. Wright, General Electric Company; G. E. Stoltz, Westinghouse Electric & Manufacturing Company, and R. W. Davis, Allis Chalmers Manufacturing Co.

General Phases of Pyrometry and Temperature Control in the Steel Industry

By O. BREWER*

TODAY a considerable number of industrial processes require the application of heat to maintain or complete the process. This necessitates some means whereby the various temperatures must be indicated. Temperature is a measureless quantity therefore the methods for indicating temperatures must be indirectly obtained by observing or comparing some measureable quantity which does vary with the temperature. Some of these would be the expansion of metals. Expansion thermometers — mercurial thermometers — change in resistance of nickel-copper-platinum wire resistance thermometers, variation in the expansion of a constant volume of nitrogen—gas thermometers, etc. The last named thermometer is a fundamental standard and has been used to a large extent in plotting the temperature scale up to 1500 deg. C. or 2732 deg. F.

This type of thermometer is very unhandy and inconvenient to operate so that a number of melting or boiling points of chemical elements have been determined and these in turn are used as a convenient means for transferring the temperature scale.

It has also been determined that the temperature scale may be accurately and conveniently defined by the increase in resistance with an increase in temperature of chemically pure platinum wire and by the increase in electromotive force with an increase in temperature of a chemically pure platinum-platinum rhodium thermocouple.

The temperature scale above 1400-1500 deg. C. or 2732 deg. F. is based on radiation laws which agree closely with the above methods and offer the only commercial means for extending the temperature scale. The radiation and optical pyrometers are used for indicating such high temperatures.

Since mercurial-pressure-expansion and vapor thermometers cannot very well be used above 600 deg. F. and as nearly all temperature indications may be obtained by platinum resistance thermometers, thermoelectric and optical pyrometers, we will deal only with these types.

Electrical resistance thermometers are usually wound with either fine nickel, copper or platinum wire. The peculiar characteristic of the wire causes it to increase in resistance with an increase in temperature. One hundred ohms of nickel with increase about .4 ohms per degree C. Platinum wire will increase a little less. This characteristic is known as temperature coefficient.

Nickel wire does not make a reliable thermometer much above 250 deg. F., while platinum makes a highly accurate and reliable one and may be easily reproduced. The coefficient of both types of thermometers are adjusted by adding or cutting off wire and then adding manganin, which has very little or no temperature coefficient. In this way standard curves are obtained for platinum and nickel thermometers so that they may be repaired or replaced at any time.

*Leeds & Northrup Company, Philadelphia, Pa.

This type thermometer is nearly always operated in conjunction with a Wheatstone Bridge, consisting of two ratio coils, a variable known resistance, the thermometer, a galvanometer and dry battery. It is usually a null or balance method.

A change in resistance of the thermometer with a change in temperature produces a difference of potential across the galvanometer terminals causing it to deflect. The variable resistance or slide wire is moved until there is no current flowing in the galvanometer thus bringing the galvanometer to its original zero position. The slide wire having been previously calibrated against standard temperature resistance curve values, which were substituted as "dead" resistance in place of the thermometer enables the temperature to be read directly from the indicator scale.

Temperature differences may be accurately indicated by substituting another thermometer in place of the variable resistance. One arrangement has enabled the flow of gas to a soaking pit to be conveniently tabulated. Another arrangement enables the temperature difference between incoming and outgoing brine to be accurately measured thus helping the efficiency of compressors used in refrigeration plants to be determined. A scheme is now being offered for recording the heating values of gas directly in B.t.u. This is known as the Thomas calorimeter.

The use of resistance thermometers is limited and careful consideration has to be given to the operating conditions.

We will now proceed to the more universally used thermoelectric system.

A number of years ago it was discovered by heating the junction of two different metals a small electromotive force could be developed. The magnitude of this electromotive force depended upon the metals employed and the temperature of the hot and cold ends. Later it was found the electromotive force of certain metals had a definite relation to the temperature. The metals most generally used today are copper-constantan, iron-constantan, chromel-alumel, platinum-rhodium.

Constantan is a combination of copper and nickel. Chromel a combination of nickel and chromium. Alumel a combination of nickel and aluminum. Copper constantan couples are in use for indicating the temperature of liquid air which is used in the manufacture of helium gas and up to 500 deg. F. The couple develops 2 to 2.3 millivolts for every 100 deg. F.

Iron constantan couples are being used for the low temperatures obtained in the manufacture of ammonia and up to 1700 deg. F. This also makes the most successful couple for determining the temperatures of sheet metal during the box annealing operation. The couple generates 3 to 3.5 millivolts for every 100 deg. F.

Chromel alumel couples are in use up to 2000 deg. F. In some cases they are known to be used up to 2200 deg. F. required in the heat treating of high speed steel. Under continual service at those high tempera-

tures, they should be checked often and replacals may be frequently needed so that platinum rhodium couples would last considerably longer and be more economical in the long run. They develop 2 to 2.2 millivolts for every 100 deg. F.

Platinum rhodium couples are installed over the range of 1800 to 2650 deg. F. They develop .5 to .6 millivolt or 6/10,000 volt for every 100 deg. F. The couple should always be carefully protected by primary tubes of non-porous porcelain and most operating conditions are such as to require an additional or secondary tube of porcelain, clay, carborundum, etc. This protects the couple from contamination by the furnace gases and is very important when the couples are to be used in a reducing atmosphere. In fact the protection of any couple has considerable to do with the success obtained from the couple and in some cases is a deciding factor as to what type of couple will be best suited for the operating conditions.

Chromel alumel couples require a neutral or oxidizing atmosphere and when used under a reducing atmosphere must be carefully protected by non-porous porcelain tubes or dense metal tubes such as nichrome or chromel.

Iron constantan couples will stand an oxidizing or reducing atmosphere without altering their calibration to any extent but when used in a strong oxidizing atmosphere will scale and should be protected by calorized iron tubes, wrought iron tubes, nichrome tubes, etc.

Commercial conditions are such that it be possible at any time to reproduce thermocouples whose E.M.F. temperature curves will closely follow the original curve. This is generally controlled in the chemical combination although various schemes, like shunt or series coils may be employed. The latter arrangements are not the best practice as frequently larger errors may occur than those originally in the wire.

There are two types of instrument now available for measuring or indicating the small electromotive forces developed by thermocouples.

The millivoltmeter or current indicator and potentiometer, true potential meter or balance method. Since both methods use some sort of a galvanometer it might be well to explain the deflection of a galvanometer works as follows:

The strength of the lines of force or magnetic pull exerted by the galvanometer coil depends upon the amount of current flowing and the number of turns. The strength of the lines of force of the magnet depends upon the kind of steel, its physical characteristic and its ability to hold or produce the same number of lines of force over long periods.

The lines of force set up by the galvanometer coil have a tendency to become parallel to the lines of force set up by the magnet, so that when a current flows in the galvanometer coil the magnetic pull exerted by the coil upon the field of the magnet must equal and balance the pull exerted by the spiral springs or torsion of suspensions to bring the galvanometer to rest.

It also follows that if the current is reduced to zero the galvanometer must return to its original zero position. If it does not then it has what is known as a zero shift and in some sensitive high resistance galvanometers this zero shift may be very noticeable.

While it is possible to connect a thermocouple direct to a galvanometer and then calibrate its scale direct in degrees, it also follows that the deflection of the needle or pointer must not only depend upon the amount of current flowing in the complete circuit but also upon the strength of the magnetic field, number of ampere turns, temperature coefficient, constancy of spiral springs, bearing friction, etc.

The amount of current flowing in the circuit then depends upon the total resistance of the circuit and the voltage developed due to the difference in temperature between the hot and cold ends of the thermocouple. The whole principle simply follows Ohm's law which states that I, the current, is equal to E, the effective voltage developed by the couple, divided by R, the total resistance of the complete circuit.

Suppose a thermocouple having a cold junction at 100 deg. F. and a hot junction at 1500 deg. F. develops 44.52 millivolts or .04452 volts, this we will call E. The resistance of a galvanometer being 300 ohms plus 15 ohms the resistance of the external thermocouple circuit then equals R. The current I will be .04452 divided by 315 or .000141 ampere 141 microamperes.

Now then if the resistance of the galvanometer is doubled which is frequently done to reduce the magnitude of the error caused when a change in resistance of the external circuit takes place, then the current I would be .04452 divided by 615 or .00072 = 72 microamperes, 72 parts in a million.

Therefore this latter instrument must be much more sensitive and delicate than the low resistance one. This small current must be produced or maintained day after day in order to read the same temperature. The total resistance very seldom remains constant due to gradual corrosion of the couple, contact resistance, temperature coefficient, etc., so that errors will creep in necessitating frequent checking if reliable and accurate readings are to be obtained.

A potentiometer or balance method is a better and more accurate one for measuring the small electromotive forces.

A simple potentiometer circuit would be as follows:

B—Battery ordinary dry cell 1.5 volts.
R—Rheostat.
S—Standard cell.
C—Standard cell coil.
A—Slide wire.
C_1—Sliding contact.
T.C.—Thermocouple.
L—Lead wire.

It so happens that this circuit is also governed by Ohm's law.

The rheostat "R" is varied until there is sufficient current flowing through the coil "C" to produce a 1R drop or fall of potential across the coil equal and opposite to the voltage of the standard cell. Since this same current flows through the slide wire "A" and as the slide wire has been made uniform in resistance the 1R drop along the slide wire is then directly proportional to the distance.

The voltage of the thermocouple is then opposed to the 1R drop along the slide wire "A". The contact "C_1" is moved until the galvanometer returns to its zero position, then the E.M.F. developed by the couple must equal the 1R drop along the slide wire to the contact "C_1".

The instrument requires no current flowing in the thermocouple circuit at the time of balance so there is no I.R. (current × resistance) drop or loss in volt-

age along the thermocouple circuit. The full electromotive force is delivered to the binding posts of the instruments, any change in resistance or length of lead wire or thermocouple may take place at any time without affecting or altering the original calibration. This is a highly desirable feature since the instrument actually protects its original calibration. Thermocouples having great differences in lengths of lead wire may be read from the same instrument without balancing or equalizing the resistances of the different circuits. This is true of no other instrument.

It was stated before the voltage of a couple not only depends upon the hot junction but also must depend upon the cold junction. Some method must then be devised to correct for the cold junction in order to have the instrument indicate correctly the temperature at the hot junction.

When copper wires are connected to the head of a base metal couple, the cold junction is at that point. Usually the head is subjected to quite a variation in temperature. This would cause nearly direct errors, therefore to eliminate such errors an efficient method is to have automatic electric cold junction. The cold junctions of the couples are transferred to the measuring instrument through the use of compensating lead wires. This places all cold junctions on the same terminal board. When the temperature at this point increases the effective E.M.F. of the couple decreases but the electric compensator increases and adds to the couple exactly the same amount it had decreased. The two effects always balance each other and are entirely automatic.

A potentiometer is really a comparison method that of comparing an unknown against a standard, very similar to a chemical balance and it is remarkable how quickly and plainly small changes may be easily detected.

Blast Furnace.

Since the pyrometer manufacturer is primarily interested in developing and perfecting instruments for indicating, recording and controlling temperatures, we will deal with some of those operations where the application of such equipment would be considerable help in controlling and regulating the temperatures.

It is gradually becoming recognized that the fundamental success of almost any operation is due largely to accurate information and control or elimination of the variables that enter into the operation.

The blast furnace seems to be one where the essential feature is to produce a certain tonnage of metal in the shortest time and with the minimum use of the necessary materials.

The blast furnace is probably one of the first industrial processes that was operated at temperatures above 1300-1400 deg. C. The high temperatures now obtained are primarily dependent upon the heat produced by the chemical reaction of the material in the furnace and upon the temperature of the hot blast. The hot blast is obtained by passing air through the checker work of the stoves. This checker work having been previously heated to temperatures around 1300 to 1500 deg. F. by burning gas produced by the furnace.

It is not an unusual practice when a stove is left on gas until the checker work has taken up all the heat that it can possibly hold but sometimes for hours after this point has been reached the gas may still be left to pass through the stove out into the atmosphere. This condition can be clearly indicated by mounting a thermocouple in the stack of each stove just above the stack valve. When the stove is first put on gas this valve is opened allowing the burnt gases to pass out the stack. The checker work of the stove being cold absorbs considerable heat from the gas, so that

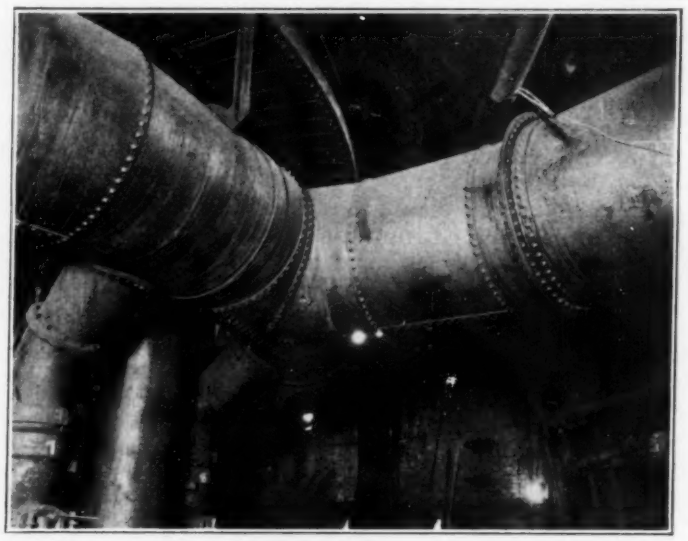

FIG. 1—*Thermocouple located in hot blast main.*

when the gas leaves the stove it has been greatly reduced in temperature. Now then, as the checker work gradually heats up, the temperature of the gas leaving the stove also gradually increases due to less heat being taken up by the checker work until a point is reached when the temperature of the thermocouple remains fairly constant and further application of heat affects very little the temperature of the gas leaving the stove. It would now seem that after this point any further gas applied passes through the stove as an

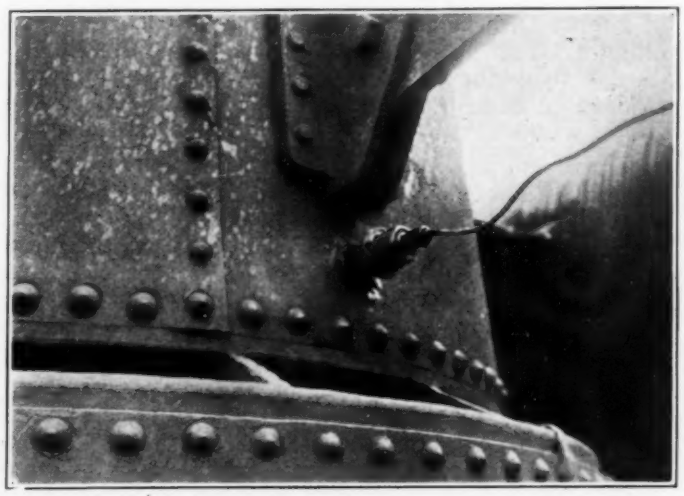

FIG. 2—*Thermocouple located at top of blast furnace stove.*

overflow or waste heat. The stove is now heated up to its limit and is ready to be put on air.

From the stove the blast passes through the hot blast main around the bustle pipe and into the bottom of the furnace through the tuyeres.

Usually there are four stoves to a furnace, it is then possible to connect a thermocouple from each stove to

a four point recorder. This instrument automatically plots the temperature and the time it takes each stove to heat up and how long the stove is on air and gas. Also it shows the temperature of gas leaving the stove; correct time at which to take a stove off gas; relative difference in temperature between stoves; the proper time to put a stove on air; leaky stack valve.

In some cases where no pyrometers have been used a record would have plainly shown when it was impossible to heat a stove up to the desired temperature regardless how long the stove was left on gas. This would indicate the checker work was defective and usually has been brought about by not realizing the excessive temperature obtained at some times and also by leaving the stove on gas overtime at high temperatures thereby forcing the checker work to considerably overheat above their rated capacity.

Such a condition would be more readily appreciated if you had the opportunity to come in contact with some of the broken down heat treating furnaces in use today solely brought about by not appreciating the destructive effect of excessive temperatures and useless overheating and the value of a good pyrometer.

It is now possible to automatically control the temperature of the hot blast of a blast furnace. This equipment has been developed at the Bethlehem Steel Company in co-operation with the Leeds & Northrup and the U. S. Patent number is 456,227.

The apparatus consists of an automatic potentiometer recording controller, relay panel board, limit switches and reversible adjustable speed motor geared or mechanically attached to the mixer valve.

The potentiometer system eliminates any errors which could be caused by variation in length or resistance of the thermocouple circuit, temperature coefficient, cold junction, etc. This assures reliability and accuracy.

The instrument being motor driven offers abundant power for operating the control discs and recorder mechanism. This assures durability and ruggedness of parts.

The recorder being a balance method enables a temperature chart 10 in. wide to be used. The open scale magnifies the readings, temperature changes are quickly and plainly noted. This assures sensivity.

There are two control discs on the recorder. Each control disc has a high and low segment. The discs are adjustable and may be easily set for any temperature. They are moved through a clutch arm by continuously revolving setting cams geared to the armature shaft of the recorder motor.

Each disc controls a dual relay. The low segment of the control disc being connected to the closing coil and the high segment being connected to the opening coil. Each relay in turn operates a main contractor switch. The closing coil of No. 1 relay connects current to No. 1 main contactor switch. This allows the motor to close the valve. The other coil of No. 1 relay disconnects the current from the No. 1 main contactor stopping the motor. The closing coil of No. 2 relay connects the current to No. 2 main contactor. This reverses the current through the armature of the motor thereby opening the valve. The other coil of No. 2 relay disconnects current from No. 2 main contactor stopping the motor.

The thermocouple is located in either the bustle pipe or in the hot blast main just before it enters the bustle pipe. No outside protection tube is used in order to secure freedom from lag and making the couple respond quickly to temperature changes.

The clutch disc on the recorder being mounted horizontally and pivoted at its center may be moved up or down when it is disengaged from the control discs. This takes place about once every three seconds or at a speed corresponding to one revolution of the setting cams. The galvanometer pointer is periodically raised once every three seconds. Now then, any movement of the galvanometer pointer is mechanically transmitted to the clutch arm at the moment it is disengaged causing the clutch arm to tilt up or down. The clutch arm is then released re-engaging with the control discs. The resetting cams come in contact with clutch arm and in returning it to its original horizontal position move the control discs an amount nearly proportional to the change in temperature. The control discs in moving to the high or low side depending upon which way the temperature changes, operate the proper relays allowing the motor to close the valve if the temperature decreases and to open it if the temperature increases.

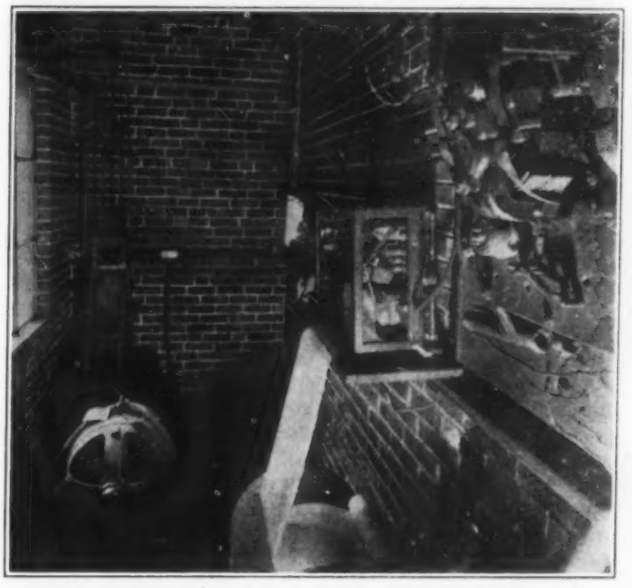

FIG. 3—*Equipment for automatically controlling the temperature in hot blast main, showing controlling pyrometer, relay panel and motor-driven valve.*

Rheostats are connected in series with the field windings of the motor in order to establish the best co-ordination between the travel of the valve and the corresponding changes in temperature of the couple when connected to the recorder. This is essential to prevent too large or too short a valve travel. When the valve is completely closed a small alarm may be sounded or a signal light flashed, indicating a new stove should be put on air. When the new stove is put on the automatic control will readjust the temperature to the proper value within 5 to 8 minutes.

Should a higher temperature setting be desirable this can easily be accomplished by simply turning a knob. The control responds quickly and the new temperature is obtained within a few minutes.

This is a decided advantage as the manual control records taken undeniably show that while the

temperature may take 15 to 20 minutes or more to reach the proper value, it may only stay at that value 10 or 15 minutes, hardly long enough to accomplish any results. In manual control the operator is not as attentive as the automatic so there is nearly always a continual falling off in the temperature. Sometimes the temperature may decrease 100 deg. F. before a readjustment is made.

The automatic control eliminates such variations, maintains a more constant temperature resulting in a more smoothly operating furnace.

A program attachment has now been added which automatically readjusts the temperature at a definite rate. This takes place after every cast with the idea of trying to keep a constant pressure.

The temperature of the metal when being tapped from the furnace can be obtained by sighting an optical on the metal stream going over the dam just below the skimmer. This would not be black body temperature and a correction of about 200 deg. F. would have to be added to get the true temperature.

Open Hearth.

Up to the present time no satisfactory method is available whereby it is practical to insert a pyrometer directly into the molten metal and determine the temperature. A platinum couple cannot be used continuously much above 2600 deg. F. and then it cannot be used at those temperatures unless it has the proper atmosphere or is carefully protected. The optical pyrometer therefore offers about the only means for indicating this temperature. The instrument consists of an accurate milliammeter, rheostat, two dry cells in series and a small special electric bulb having a tungsten filament in the shape of a hairpin. The current through the filament is adjusted by turning the rheostat until the brightness of the filament blends with the object being sighted on. It is an instrument calibrated for black body temperature, that is, a body that absorbs all radiation falling upon it and reflects none. This is approached by sighting down a heated closed end tube, or on a graphite block or in a furnace uniformly heated and where it is not easy to distinguish the outline of the material in the furnace.

Unless it is used under black body temperature it will always be necessary to apply correction factors to obtain the true temperatures. When it is only necessary to reproduce temperature conditions from time to time it usually is not necessary to know the true temperature. The instrument will always read the same under the same conditions. It should not be sighted through smoke or flame and the degree of accuracy will depend largely upon intelligent handling. An instrument of this type may frequently be condemned because it would not give this or that temperature, when it is really up to the judgment of the operator to determine if it should be used under such conditions.

It offers one advantage in the operating of an open hearth furnace in that it may be sighted upon different parts of the brick wall, care being taken to sight upon the same place or places not subject to much reflection. This sighting may be done during reversals and when the flames do not interfere. From such readings it could be possible to operate the furnace so that the temperature of the brick could always be kept below the danger point. Another way would be to countersink a hole in the brick and then sight the optical at this place each time. Of course this marking would have to be done before the furnace was started.

Another scheme which has been suggested is to mount a silica block in the roof or wall. This block would be flush with the inner surface. A hole large enough to insert a platinum couple would extend down the center and end about 2 in. from the inner surface. The thermocouple would be connected to a sensitivity instrument and the depth of immersion regulated until a reading around 2500 deg. F. is obtained. The couple should then be firmly fastened in place. After this the trend of the temperature could be noted. While there would be a lag between the couple and the inner wall due to the temperature gradient, nevertheless it would offer a means for detecting which way the temperature was changing. Comparison between the couple reading and the inner surface could be made with the optical. The difference in temperature would probably change from time to time but one scale could be adjustable and reset to correspond to the optical reading.

It is possible to mount couples in the regenerators and experimental work is being carried on whereby it

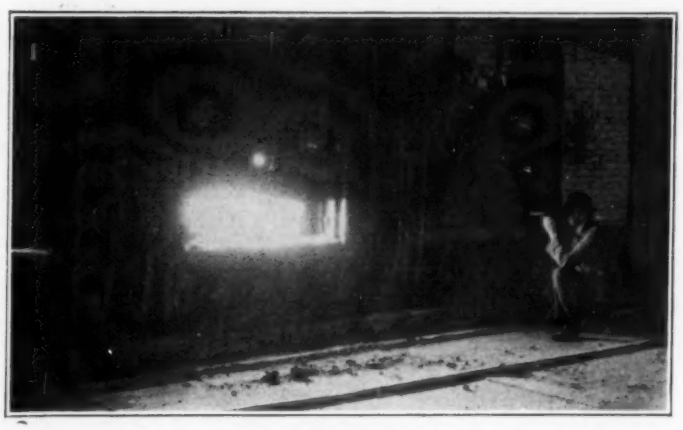

FIG. 4—*Measuring temperatures in open hearth furnace by means of optical pyrometer.*

may be possible to make the reversals automatically from time temperature.

A thermocouple may also be located in the stack so as to give temperature indications of the gas passing up the stack. This is becoming a vital point in the modern power house where the maximum energy must be obtained from the fuel consumed to assure high operating efficiencies. Excessive stack temperatures indicate waste heat and poor combustion or combustion taking place at the wrong time which in turn prevent the steel from absorbing the maximum amount of heat from the gas.

The apparent temperature of the steel when tapped from the open hearth into the ladle may be gotten by sighting the optical on the stream of metal just as it leaves the spout. The steel under this condition is not a true black body therefore a correction would have to be added to give the true temperature. (U. S. Bureau of Standards pamphlet Temperature Measurements in Bessemer & Open Hearth Furnaces, May 8, 1917.)

The temperature of the steel going from the ladle into the ingot moulds may be gotten by the same method but the steel is under the same condition as before and would not be a black body. Now then if some practical method could be developed for determining the rate of cooling of the steel while in the ladle, it could be poured into mould at the desired

temperature without any guess work. In the manufacture of steel castings which have to be carefully tested under hydrostatic pressure, the pouring temperature is a deciding factor as to whether the castings will be of uniform structure and pass the tests successfully. All castings not passing the test must be remelted since they cannot be patched at the defective points. In some cases the temperature of every heat, together with the weight, chemical analysis, the time held in the ladle and the temperature of the steel poured into the ladle, from the ladle into the first mould together with several moulds selected at random are being plotted upon cross section paper in order to better the quality and arrive at proper pouring temperatures and the proper time to hold the steel in the ladle. The tests so far indicate the amount of skull left in ladle on a 4000 pound heat (this is an electric arc furnace) has been reduced as low as 50 pounds.

Apparently the difficult part so far is in trying to determine the rate of cooling of the steel while in the ladle and this in turn has something to do with the temperature to which the ladle has been heated.

Soaking Pits.

There has been practically no improvement in usual method for obtaining temperatures of the ingots while in the pits. The present method is for the operator to make visual observations when the lid has been pushed back. There is probably no doubt but what an experienced operator will have a fair chance to judge temperatures this way especially if practically the same temperature is reproduced from day to day. When an ingot is placed in a furnace whose walls are much hotter than the ingot it is seldom appreciated that the ingot may appear hotter than it really is. This is caused by the surface of the ingot reflecting some of the light falling upon it from the bright walls. In relation to the bright walls the ingot will appear dark but this is due to the contrast. An optical sighted on the ingot at this time would read high because the ingot would not be under black body conditions. As the difference in temperature between the ingot and the walls is reduced less light is reflected by the surface of the ingot and more accurate readings could be obtained. Under such conditions the optical should be sighted in between the ingots or on some spot that has very little chance to do any reflecting.

Recently it has been possible to record the temperature by mounting a platinum-platinum rhodium thermocouple protected by a primary porcelain and secondary carbofrax tubes through the lid. The couple moves with the lid.

We have been advised the record showed when the steel was not "soaked" sufficiently as the temperature of the couple decreases should the pit be tied down too soon and just the reverse occurs when the steel has a liquid center. The record will show the reverals with the time. Numerous checks taken with the optical prove the couple reads very close to the steel temperature.

When the steel has reached the desired temperature and the pit is tied down the decrease in temperature of the couple will be very slow. Steel has been rolled by this method but intelligent use and good judgment were required.

Like anything new there was quite a few kinks and considerable time had to be spent to iron out some of them. The cost of maintenance was rather high at first due to pyrometer tubes breaking but we believe this has been overcome to large extent. The outfit would have the advantage of helping to eliminate or reduce to a minimum, excessive temperatures.

Forging Temperatures.

The temperatures of large forge furnaces where half the ingot may protrude from the furnace are very difficult to record so that the readings will have any definite relation to the temperature of the ingot. Experimental tests showed the surface of a large ingot may be 100 deg. F. hotter than the center after it had been held for a considerable time in a furnace operating around 2400 deg. F. When the ingot was removed the surface cooled rapidly and the center slowly so that after it had been out of the furnace for about 20 minutes the center can be 140 deg. F. hotter than the surface.

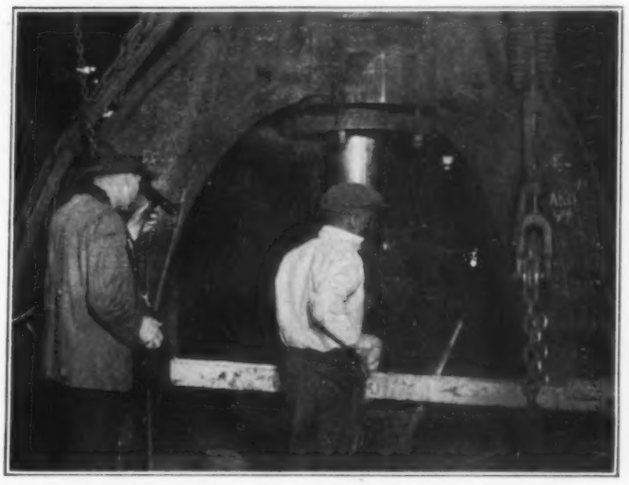

FIG. 5—*Measuring temperature of a forging by means of optical pyrometer.*

Two platinum-platinum rhodium couples were located about four feet apart. One on each side of the ingot. They were connected to a recorder. The temperature gradient between the couples was approximately 130 deg. F. and it was determined by the optical after the surface of the ingot passed approximately 1800 deg. F., the temperature up to the forging heat always remained between the temperatures of the two couples. The couples in this experiment were a decided advantage in maintaining the desired furnace temperature.

Results prove it is very difficulty to specify a definite rate of heating for large ingots and the best forging temperatures due to so many variables. Better results can only be gotten by careful study of data and information gained from years of actual experience.

Generally where small billets are to be forged, the furnaces are large enough to hold maybe four or five bars. A recess is made in the rear wall, depending of course upon the type of furnace and a platinum-platinum rhodium couple is inserted. The couple can be mounted so as to be removable or moved up or down at will. A space is usually left between the first two to be forged when placed in the furnace and the couple is put in this space. The couple is then connected to a signalling potentiometer recorder located in the superintendent's office while a deviation indicator and red, white and blue signal lights are mounted at the furnace for the operator.

The deviation indicator is calibrated to show only temperatures plus or minus 200 deg. F., from a set temperature. The instrument in the superintendent's office is set for the temperature desired. The deviation indicator and signal lights are controlled by the recorder. The zero on the deviation indicator and the white signal light now correspond to the temperature desired.

When the temperature is 200 deg. F. below the setting the indicator points to minus 200 and a blue light is flashed. The furnace attendant simply has to look at the indicator to tell the number of degrees the furnace is off from the proper point and as the pointer approaches zero he regulates the burners accordingly, gradually slowing down the temperature and preventing the furnace from going beyond the set temperature. When the correct temperature is reached the indicator points to zero and the white light is flashed. Should the temperature go past the setting a red light is flashed. These signals attract the attention of the operator (and some times the superintendent). The lights are visible at all times.

It is not necessary for the operator to remember a large number of temperatures or to do any manual operation to obtain the temperature. The temperature indicator being directly at the furnace saves the operator's time generally spent in going back and forth from a centrally located pyrometer.

The outfit has the tendency to reduce to a minimum large temperature fluctuations. Temperature readings are magnified enabling the operator to have advance notice which way the temperature is changing.

The thermocouple being located between the billets gives very close to the billet temperatures.

The records being in the superintendent's office give at a glance the temperature of each furnace. The arrangement offers an excellent method for regulating the heat treatment and production schedule for the various furnaces.

It transfers information into the laboratory enabling a better study to be made of the heat treatment for further reference.

Quite a few of the large automobile concerns have practically standardized upon this system. It offers protection to the user, especially in those cases where the turn over in labor is large since green operators can be very easily broken in.

Rolling Mill.

No satisfactory method has yet been developed whereby it is practical by the use of a thermocouple to record the temperature of the bar as it comes from the rolls. A method which has some promise is to set up a radiation telescope near the rolls and sight it at the bar. This may be connected to a potentiometer recorder and every time a bar passes in front of the telescope a record is made of its apparent temperature. The reading under such conditions may not be true temperature. There would be practically no scale on the steel but temperatures should be checked and compared with the optical.

The temperature may also be obtained by the optical pyrometer.

Heat treating furnaces, japanning ovens, paint ovens, enameling ovens, core ovens heated by electricity are easily controlled automatically. The general practice is to have the switch connecting the current to be electrically operated. Usually these switches break large currents and in turn are operated by relays. The relays take very little current and are designed to break their own circuit. The relay has a closing coil and an opening coil. The coils in turn are energized by switching on and off the current through the recorder control discs. The closing coil is energized when the temperature is low. This pulls in the relay contact which is then mechanically held in as the

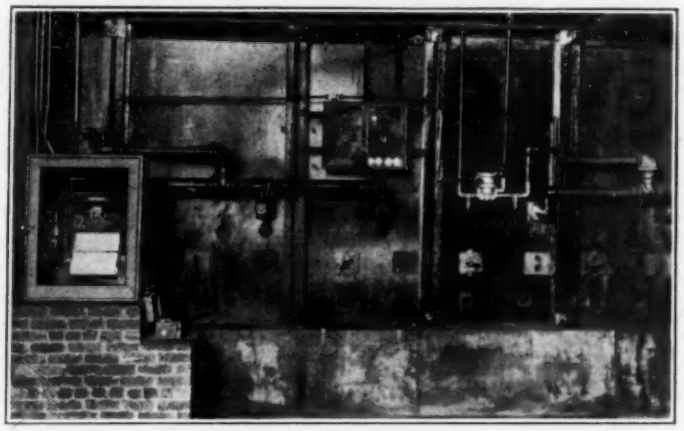

FIG. 6—*Equipment installed on gas heated continuous furnace for automatically controlling two zones at two different temperatures.*

relay in closing "breaks" its own circuit. The contacts on the controller are then relieved of any excessive sparking. When the temperature increases and the control contacts touch on the high side, the opening coil is energized operating a plunger which disengages the mechanical interlock. The first operation connects current to the main contactor coil causing it to pull in thereby connecting the current to the heating elements. The second operation disconnects the current from the main contactor coil allowing the switch to drop out in turn disconnecting the current from the heating elements. This is the off and on principle and gives excellent control when the controller and couple have the ability to quickly detect small changes in temperature.

In some cases a two-point controller may be used. One couple located in or near the furnace resistors and

FIG. 7—*Recording controllers automatically controlling temperatures of both gas and electrically heated continuous japanning ovens.*

another in or near the work. It is then possible to control the temperature of the resistors from the temperature of the work. Both couples can be made recording. Another method is to have two couples recording, and control from only one couple. When temperature fluctuations are rapid the best method is to have individual control.

Furnaces using oil or gas are now being controlled by automatic electrical valves operated by potentiometer regulators more efficiently than was possible by manual regulation. They nearly always effect a saving in fuel and time and more constant temperatures are maintained resulting in a more uniformly heat treated product.

The use of electric furnaces and ovens is rapidly increasing. Most of the automobile fenders are now japanned and baked in electric ovens automatically controlled for temperature from central stations. This results in a considerable saving of labor and time, increases production and turns out a better product.

Gears, tools, dies, jigs, etc., may be heat treated in electric hump furnaces whereby it is possible to control the rates of heating. The temperature records show when the steel is passing through its critical range and having control of the time temperature factor above the critical range, the grain size can be regulated or reproduced.

In closing we might state:

The heat treatment plays a highly important part in the success of steel in the finished product such as gears, axles, cam shafts, pistons, connecting rods, ball bearings, sheet steel, jigs, tools, dies, etc. Fortunately

FIG. 8—*An installation of Hump mehtod equipment for production heat treatment of automobile transmission gears.*

this is now recognized by all large automobile concerns and has been brought about by higher efficiencies obtained through accurate information and control of the variables during the heat treatment.

Careful consideration should be given to the location of the couples, the type of couple, the number of couples, the limitations of the temperature system, what is expected of it, what it is to do and what it is capable of doing, the temperature uniformity of the furnace, maximum and minimum rates of heating, when the steel is in the furnace, etc., if the best results are to be obtained. Sheet annealing, carbonizing, pot annealing all require that the relation between a couple in the work and a couple in the furnace be established if the best results are desired.

DISCUSSION

F. G. Allen*: Mr. Chairman, I am afraid my experience with pyrometers has been too limited to be of interest. We have to use pyrometers, of course, but when we do use them and get in trouble, we always call on Mr. Brewer or Mr. Thorp to help us out.

I think Mr. Brewer could describe one of their installations in Elyria, which has one control located within the other, with interest. He may have other applications using a similar set-up. I am sure that such installations would be of interest to some of the steel men, as they may have applications requiring the same treatment.

P. Justice†: The only place we have pyrometer temperature control is on enamelling ovens, and on the babbitting machines for automatically babbitting the connection rods. Of course, they are working out very nicely. In babbitting the temperature is around 850 degrees, and the enamelling ovens are 225 and about 300 degrees.

These are the only two places that we use any temperature control in connection with furnaces.

They have a very extensive heat treating department at the Automobile Machine Company. I don't know if there is anybody here from that plant.

Frank B. Poto*: I don't know whether I can give any information. I came up here more for information.

I would like to ask Mr. Brewer what the success would be with a radiation pyrometer on rapidly moving steel for controlling the finishing temperature? Would there be a possibility of getting the temperature in time?

O. Brewer: Does it take about 17 seconds for the bar to pass? Is it a long bar?

F. B. Poto: Yes, I should say it takes 17 or 18 seconds. The strips vary somewhat in length—about 50 feet, I should say, average.

O. Brewer: You would probably have plenty of time there.

We are trying to get the temperature now on a pipe about 10 feet long where we are limited to about 17 seconds. Of course, it may not be the true temperature, it is more likely to be the apparent temperature.

F. B. Poto: That would serve the purpose, I think.

O. Brewer: You should check it periodically to see if it is correct.

F. B. Poto: With an optical pyrometer on about nine gauge material, wouldn't it be possible to get the temperature as well as with the radiation pyrometer?

O. Brewer: That will depend on the condition of the steel. If there is no scale on it, you would come close to the true temperature.

F. B. Poto: What I was trying to make out is, that the thin gauge cools so rapidly, wouldn't it take more or less time to make a comparison.

O. Brewer: Well, if it cools rapidly, you have to check rapidly.

The optical pyrometer would come closer to the correct reading than the radiation pyrometer. Under conditions where the steel first comes from the roll, where there is practically no scale on the steel, there may be 40 deg. C. difference in reading between the radiation and the optical pyrometers.

F. B. Poto: We have a continuous annealling furnace over there, jobbing mill plate anywhere from 14 gauge up to a quarter of an inch. The sheets are only in about two and one-half minutes, and we are in-

*Industrial Heating Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

†Engineer, Chandler Motor Car Company, Cleveland, Ohio.

*Chemist, Otis Steel Company, Cleveland, Ohio.

terested in getting the temperature of the sheets in the furnace. We have to carry the furnace temperature above the critical range in order to bring up the sheet to the proper annealling point in that short time, or normalizing, I should say, just to crystallize the steel, and it seems to me the thermo-couple in the furnace wouldn't tell us very much. We have the flame both on top and coming up from underneath.

O. Brewer: That is really a tmeperature problem. With the thermo-couple you could hold the furnace at a given point.

F. B. Poto: Yes, we could do that. Of course, it comes off the mill at different temperatures, too.

O. Brewer: You may be able to determine the temperature with an optical pyrometer, and get some relation that way. Where you have to depend on the human element it is very difficult for any optical pyrometer to eliminate that element. The only thing the pyrometer will do, is to help the operator to determine the proper temperature.

F. B. Poto: Fortunately, we have quite a fair range to go on in the soft steel. It is a pretty good problem to normalize that steel at just the proper temperature.

O. Brewer: It may be possible to control the furnace automatically, and keep it at a certain temperature all the time.

If it is a case of bringing the furnace up to the proper temperature, and then allowing the sheets to stay there long enough to bring them up to that temperature, it would be simple. But they are in such a short time it is really a time temperature problem and there is another phase to the problem; that is, the higher you carry the temperature of the furnace, the more sheets you can pass out of the furnace providing there is no limiting factor such as the effect of rapid heating upon the quality.

P. D. Manbeck: My experience with pyrometers is very limited. I found that if you don't know how to use them, sometimes they give very peculiar results. One has to be versed in their use as well as to be able to manipulate just so many switches.

L. A. Terry*: We have a large variety of makes and styles of pyrometers, due to the fact that each operating department buys its own instruments, applies them as it sees fit and turns the repairs and maintenance of the instruments over to the electrical department. This is not an ideal condition.

In one case, we have a gas heated galvanizing kettle for galvanizing various sizes of pipe. A company undertook to install a pyrometer which would automatically regulate the gas and keep the temperature of the metal between 835 and 850 deg. F. After considerable experimenting, it was found that it was not practical because the temperature change could not be anticipated and the gas regulated quickly enough to hold the temperature within the small working range.

I would like to ask Mr. Brewer if the Leeds & Northrup Company have an instrument that could be applied to this job.

O. Brewer: In regard to the first question about the galvanizing tank—it is very doubtful whether it can be accurately accomplished for the simple reason that the heating efficiency of the galvanizing tank is very low—that is, the way the heat is applied. Then you have another factor to take into consideration; you should have a very sensitive recorder or an anticipation recorder controller, because after you shut the heat off, you have such a large mass of metal that it still absorbs heat from the walls even though the fuel is completely shut off. The tendency is for the metal to go past the control point on the heating and cooling. Careful consideration must be given to this one factor in order to work out successful automatic control.

The next question was about the ingots coming from the soaking pit, I believe.

L. A. Terry: I was wondering if you could record the temperature with an optical pyrometer.

O. Brewer: Not that I know of. You have a very difficult problem there, because the ingots are moving all the time.

L. A. Terry: Couldn't an optical pyrometer be sighted and the temperature recorded?

O. Brewer: Not without manual operation. You could mount an optical station there and connect it to a recorder, and set the current in the lamp somewhere near the temperature of the ingot, but the final operation would have to be performed by balancing the optical pyrometer against the ingot. You have a difficult problem there, as long as the ingots coming from the soaking pit have scale on them.

L. A. Terry: Radiation wouldn't be quick enough to record it?

O. Brewer: No sir. In regard to the galvanizing, we usually use a meter light system, put the meter and lights on the wall or near the tank, and locate the recorder in the superintendent's office. That takes the recorder off the floor entirely, and it also protects the recorder. At the same time it gives the tank operator the temperature indications in the most simple form, eliminating his performing any manual operation to obtain the readings.

Regarding controlling the galvanizing tank automatically. If it were electrically heated you could probably do so very accurately because you would only have to overcome the radiation losses, but when heated by oil or gas such factors as the oil and gas pressure, location of thermocouples, heat inertia of the metal, sensitivity of the control instrument, etc., must be given careful consideration for each particular tank.

S. L. Henderson*: I don't believe I have anything of interest to add to the discussion. If I said anything it would be repeating what Mr. Brewer has already said. Mr. Brewer has covered the subject in a very capable manner, he has given us very valuable information on methods of obtaining temperatures in the steel mills and blast furnaces, therefore it is my wish that we extend him a hearty vote of thanks.

It may be of interest to some to know of the earlier methods used in obtaining temperatures at the blast furnaces. One of the first methods, I believe, was to place an iron ball of certain dimensions in an opening provided at the blow pipes of the furnace, and after it became heated, it was then dropped into a small receptacle containing a fixed amount of water, and if the water was evaporated in a certain time, it would indicate a relative temperature. Just what the temperatures were I am not in position to say.

Another or later method was the use of a long type of instrument, rectangular in shape, standing six or seven feet high, placed in a brick house some

*Testing Engineer, National Tube Company, Lorain, O.

*Elec. Supt., Central Fces., A. S. & W. Co., Cleveland, O.

distance from the furnace. This instrument recorded the temperature on a circular 24 hour chart. It operated on the expansion principle. A small diameter tube, covered with a heat resisting insulation, connected the instrument with the furnace. Great care had to be taken that the tube covering was always intact, or the temperatures would be affected. The tube was filled with mercury. An expansion chamber was connected to the blast main near the furnace.

The two methods of obtaining temperatures apply only to that of the blast air, which is heated to approximately 1200 deg. F. before entering the furnace. To my knowledge, very few attempts were made to secure temperatures of the iron at that time.

In conclusion I might add that the present types of pyrometers have rendered it possible to secure not only high temperatures, but accurate temperatures.

A. F. Jones*: I'd like to ask Mr. Brewer if the Leeds & Northrup Company, instead of using indicators at the heat treating furnaces, do not remove the human element entirely from the regulation of the furnaces and use an automatic valve, and if so, is that an on and off type of valve in that it shuts the oil or fuel entirely off, and when it drops to a certain temperature, turns it on again?

O. Brewer: We have no valves of our own make. There is a good valve on the market, made by the National Production Company in Detroit. As I understand it, this valve has a high and low setting—that is, the high setting will go about 10 to 20 deg. above the temperature desired in the furnace, while the low setting will go the opposite way. Should the temperature be low the gas is allowed to pass through the large opening, and if the temperature is high, the gas or oil passes through the low opening, increasing or decreasing the temperatures accordingly.

I think all of them work on about the same principle, that is, they operate about 10 per cent of the full supply. The potentiometer when connected to such a valve has a 10-in. chart and gives very close control while if you attempted to get the same results with a chart five inches wide, you would have to work practically twice as close. Furnaces are being controlled today more efficiently with automatic regulators than has been possible with hand control.

F. Q. Thorp†: About all I have to say is that it was a mighty interesting and instructive talk. It is entirely within the realm of possibility to look forward to the time when practically all applications will be automatically controlled. That control can be accomplished not only in electrically heated devices, but also in gas and oil fired applications.

I was particularly interested in Mr. Jones' question, about a heat treating furnace heated by oil or gas. Such control can be accomplished by the gradual motion of the valves, operated by a pyrometer. Our work has to do mostly with the galvanometric type of instrument.

If you want control at 1600 deg., we will say, the index can be set at 1600, and just above and below the 1600 point will be located two small contacts on which the pointer will be depressed at frequent intervals. If the pointer strikes the high contact, the circuit is closed on the high side, and the valve will close; when the temperature drops, the low side circuit is closed, and the valves automatically are opened. You have a valve control mechanism with a small motor contained in a box; on each side of the box will be located a valve one for oil and one for the air. In the balanced type of valve, if the pointer strikes the high contact, the motor will run for a short period of time, shutting off the valve gradually, and controlling the oil and air in proper ratio. Then if the temperature still remains too high, the pointer will strike the high contact again, and start the motor in the same direction, only this time at a slower rate of speed, so that the control is gradually established. Then by that time your furnace has started to cool, and the pointer will drop correspondingly. When the temperature is low, it will automatically start upward again. So a very close control can be accomplished with very accurate results. In that way, temperature can be controlled within a very short time, and within very narrow limits.

A. F. Jones: I'd like to ask further if this variable contact, for instance, the pyrometer staying on the same furnace the first heat for one bunch of forgings being 1600 deg. and the second heat at 1400 deg. could that contact be moved from 1600 deg. to 1400 deg.?

F. Q. Thorp: Then, we can go one step further and get an automatic time temperature cycle control in annealing furnaces for instance where a certain temperature is desired at a certain rate of increase or decrease. You can raise the furnace to that temperature over a pre-determined time by the insertion of a cam in the instrument, the cam being operated by a small motor, causing the index to move up automatically, so that the control functions as it goes up. The cam can be so designed as to keep the soaking temperature in the annealing process for a given number of hours. That temperature will be maintained in the manner described previously. The same process is carried out when reduction in temperature is desired.

H. C. Cronk*: Mr. Chairman, I think it is mighty gratifying to hear a paper so thoroughly written as this one, particularly as I believe this is our Association's first attempt on this subject. To my knowledge, there never has been a paper in this Association on pyrometry, and Mr. Brewer has certainly covered it in a very thorough manner.

I would like to have Mr. Brewer explain to us who are uninitiated in pyrometry what he means by this term "black surface". I believe it would be interesting to most of the people here who are not initiated in the use of pyrometers.

Mr. Brewer also mentioned the "Hump Furnace". If there is anything about the hump furnace to be told, we ought to hear about it, since he brought the question up himself, possibly it is not out of place to ask something about it.

To me, one of the most interesting parts of Mr. Brewer's paper is high temperature pyrometry. I am not attempting to go into history; I know nothing about it, but the ordinary temperatures, for a long time have been 1300, 1400, 1500 and 1600 degrees and these temperatures can be handled more or less readily. But when you get to 2000 deg. or 3000 deg. it gets to be another problem, and it is mighty interesting to hear that some work has been done up around 2500 deg., or possibly higher. Mr. Brewer mentioned 2500 deg. How much higher he can go, I don't know, but that is certainly interesting, and it might be interesting for

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us to hear from him as to how much higher he can go with the ordinary commercial couples, as no doubt that is the limiting factor, therefore if we could get some idea of the maximum temperature the present couples will stand, I am sure that, too, would be interesting.

I'd like to ask also about radiation pyrometers in work such as open hearth. There is one particular company, probably known to pyrometer men who advocate radiation pyrometer for open hearth work such as Mr. Brewer has mentioned here this evening. I'd like to hear what we might do, either from the author, or any one who might be in the audience, on radiation pyrometers for temperature prohibitive to couples.

O. Brewer: Probably the simplest way to describe a black body is to take a tube closed at one end and insert that tube in the furnace, and then sight down the tube. It would be a very poor reflector.

If you have a piece of carbon, and a piece of platinum at the same temperature, the carbon will appear about 2½ times brighter than the platinum, due to what is known as the emissivity power of the two different materials. The carbon would be approximately a black body as it absorbs all radiation and reflects none.

If you look into a furnace where it is very difficult to see the material in the furnace, that would approximate a black body.

The platinum thermocouple cannot very well be used continuously much above 2650 deg. F. The couple has to be very carefully protected against contact with the furnace gasses. Not only that, but the continuous use of the couple at the extremely high temperature causes it to crystallize and rapidly change in resistance which greatly alters the calibration of a deflection indicator or recorder. It generally decreases the electromotive force of the couple, and that is a limiting factor of the high temperature.

The radiation pyrometer measures the heat waves as well as the light waves, whereas the optical pyrometer measures the intensity of a narrow band of radiation. The radiation pyrometer is also affected by the gasses between the telescope and the body. Water vapor will also affect the reading of the radiation pyrometer. If the radiation pyrometer has mirrors in it, and the mirrors are dirty, that will affect it also. Usually the errors on radiation pyrometers are much larger than optical pyrometers—that is, if you sight on iron oxide with a radiation pyrometer, and sight on iron oxide with an optical pyrometer, the radiation pyrometer may read 40 deg. different than the optical pyrometer.

When you use a radiation pyrometer for sighting into a furnace, it takes in a definite area. You must also have a certain-sized area, and it includes the radiation from that area, whereas with an optical pyrometer you pick out the point. Re-radiation down the telescope greatly affects the accuracy of some radiation pyrometers. The success of either type of instrument will depend on intelligent use to know whether you should sight on the object, and to know when you have black body condition to give the true temperature.

G. R. Roemer*: I remember one experience I had during the war days when they tried to roll what we would call a copper billet—that is, the billet was stood up on end, was put in a mold, and copper poured around it. They shipped that into our plant, and we put all kinds of pyrometers in the furnace, and watched the copper run off the steel. We had intended to make shells out of it.

A. W. Mohrman†: In this particular instance, the billets were placed in the furnace, and the first thing that happened was that the copper ran off the steel without having the steel hot. Well, our metallurgist came down hot-foot. We got a lot of pyrometers and put them in the furnace and tried it over again. The same thing happened over again.

Mr. Roemer got excited at the time and wanted to know if the electrical department couldn't do something. Some months before, the General Electric Company had come in for some rolling data which they had obtained with an optical pyrometer such as Mr. Brewer explained, so I dissected this little device very thoroughly to see what it was made of. I conceived the idea that a carbon lamp would do the same thing, so I got a couple pieces of carbon paper, stuck the lamp inside, and we tried that. That little instrument did wonders. I was about 10 feet higher than I ought to be, and our superintendent came down all smiles.

When this little carbon lamp was set at a certain temperature, or the meter was put alongside of it, the voltage was very considerable, and that would give us on and off temperature. We took the steel out and rolled it.

The only thing I can say, is that that little instrument Mr. Brewer described, is the only instrument that knows exactly what we need. I don't know if mine was too slow, or too fast, but there was something wrong.

On a number of other occasions we wanted to know the right rolling speed and the right rolling temperature. This instrument came in handy again, and we placed the lamp in the pulpit where the operator was. The heat wasn't exactly right according to the roller. We took his word for it and bought an apparatus that checked it a whole lot closer.

Mr. Paine is here. He talks about getting the temperature of the finished bar. I don't think it will be very long before you will see some device down there that will tell us something about it.

Our rolling speed is seven seconds. We have come to the conclusion that that is our right speed. It is a pretty hard thing to get all our temperatures, because the steel goes through so fast. But with wireless and some other things we have now, I think I am going to get something that will respond a whole lot quicker through one of these vacuum tubes. The response amplifies the current something like 100 to 1000 times, and by getting this response so quickly, it will tell us pretty closely what that temperature is. If we can do that you will see a new apparatus on the market.

R. S. Sawdey*: I'd like to ask Mr. Brewer if he has any device for telling when the motors on recorders stop for any reason, allowing the temperature to keep on going up? Is there any device for telling when the motors are out of order?

O. Brewer: Yes, you can mount a couple of extra contacts right beneath the governor contact, so if the

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motor stops the governor closes these contacts. The contacts are connected in series with either the main contactor, or an opening relay.

W. D. Smoot†: Mr. Chairman, it is getting pretty late to prolong this discussion but there is one question I'd like to ask and that is—whether Mr. Brewer has seen in service a continuous electric carbonizing furnace, or a continuous furnace using oil or gas as a fuel, and how can the furnace temperature be measured?

O. Brewer: I cannot recall one. There is a company here in Cleveland who has a continuous sheet annealing furnace. The temperatures of the furnace itself is very easy to measure, but to record the temperature of the material passing through the furnace would present a very different problem.

G. R. Roemer: I'd like to ask the speaker if there are any instruments made besides platinum—if any experiments have been made with iridium which has a higher melting point?

O. Brewer: Yes, there is such a couple, platinum-iridium, but I believe it is harder to reproduce, and the higher temperature better than the platinum- iridium.

†Acme Machine Company, Cleveland, O.

Experiences With Multiple Feed, High Pressure Lubrication

By LOUIS R. HUMPTON*

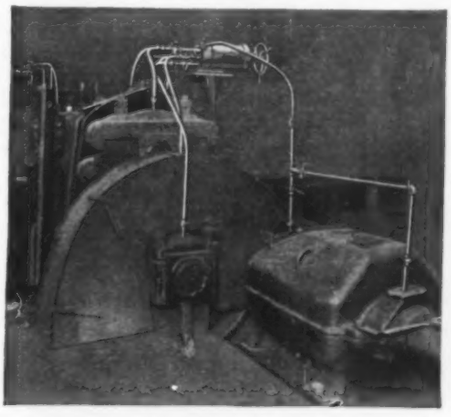
IT is a matter of constant surprise to me that in so many manufacturing plants and steel mills so little attention is given to the solution of problems connected with lubrication. In a large number of cases the same methods are in use today as were followed 50 years ago. Although new methods of improved lubrication have been brought forward, perfected, and although these have been successful in eliminating accidents and adding plant efficiency wherever used, it is a shocking fact that in so many big establishments the old fashioned, antiquated oil can is still the mainstay of lubrication. The only explanation of this condition is the existence of the "if it was good enough for father it's good enough for me" spirit. And this despite the large number of mishaps to men engaged in oiling by the old fashioned methods and the number of fires, some of them quite costly, which result from the spattering of lubricants.

Considering the matter merely from the standpoint of accidents to oilers, statistics tell an impressive story. Companies writing compensation insurance in Pennsylvania, covering all kinds of industries over a period of years, have compiled figures showing that out of 1,542,349 compensation days lost as a result of accident, 104,971—or nearly 7 per cent—were due to injuries to workmen while oiling or cleaning machinery.

"Safety First" signs were probably displayed in all of the plants where these accidents occurred, but machinery made safe—and it can be made safe—is a great deal better than "Safety First" signs.

Now from the standpoint of efficiency. Have you ever considered how many bearing caps you find which have drilled with a one-eighth of an inch oil hole? It is expected that enough oil can be squirted into this hole to lubricate the bearing perfectly—and possible the expectation could be fulfilled if the oiler or machine operator was able to force a stream of oil from ¼ to ¾ of an inch in diameter into this ⅛-in. oil hole. But it can't be done. The oiler wastes a good deal of time trying, but he never becomes proficient at an impossible job.

I have often wondered—to point to another phase of the question—whether it would not be profitable to drill oil wells around the machine foundations in some of our large mills, so much oil is spilled and wasted in plants where the antiquated methods still prevail. And with this spillage, and with oil lying around on the floor in puddles, the menace of fire is apparent. Many a blaze is directly traceable to this cause. In my own plant we have had two very bad fires—under the old conditions—caused by sparks igniting oil which had collected on the floor. Two 200-hp. motors were destroyed by the fires.



Lap weld finishing mill, and 24 h.p. Westinghouse motor lubricated by one Keystone Manifold Safety Lubricator.

We have been all through the question of lubrication in my plant, making progress slowly, but at any rate constantly experimenting and trying to improve. We think we have solved our problem pretty completely now.

Take for example, our cold scarfing machine for scarving bevel edge on plate or skelp iron for making lap weld boiler tubes. This machine is driven with a 50-hp. motor and is subject to very hard service at all times. It has 12 bearings. Formerly we used ma-

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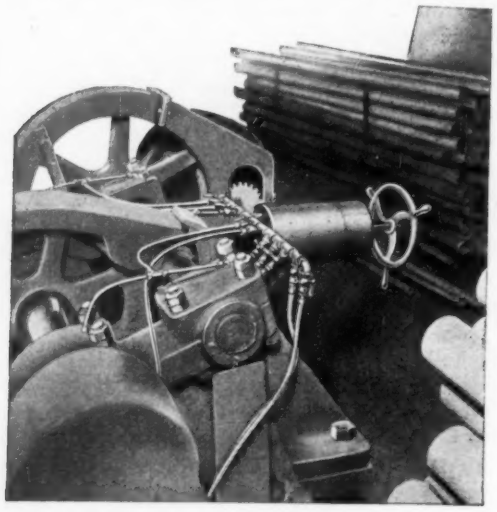
chinery oil to lubricate it, with oil rings to carry the oil around the shaft.

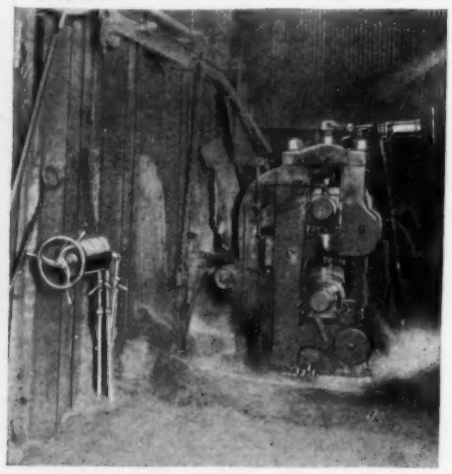
But we were constantly having trouble, necessitating frequent shut-downs for repairs. Because of cold weather, because of dirt getting into bearings, the rings would not follow around the shaft. Consequently the bearings would run hot.

Then we tried sight feed oil cups, but they would not stand the vibration. The thread on the stem



Lubricator installed on tube straightening machine feeding all seventeen bearings.

would become worn, and shut off tight. The bearings would start to heat. As we could not get at the bearings while the machine was running, it would become necessary to stop the machine. The delays due to complete stoppage were frequent. Another trouble with the oil cups was that the stems would become loose, work out and run oil cup dry. We tried ordinary grease cups, but there was danger in getting at them and we could refill them only when the ma-



200-h.p., lap-welding mill equipped with lubricator. Pipes from lubricator lead down under floor, and come up under roll housing connecting with brasses.

chine was standing still. They were an improvement over the oil cups, it must be confessed, but they were not entirely satisfactory.

Finally we tried a manifold safety lubricator, connecting it to each bearing, using half-inch standard gas pipe. With that we ran the machine continuously for six months without any delay or trouble of any kind. Not only were we saved the loss of time incident to shutting off operations, but we made a considerable monetary saving. Formerly, we had used one barrel of oil each week, at a cost of $15, but with the manifold safety lubricator we cut the oil consumption down to the point where the grease itself cost us only $8 per month—as against $60 previously with oil. Our babbitt metal bills have been cut 75 per cent. And as I have indicated before, we eliminated all fire risk. Since we installed the first lubricator on this machine, we have placed 40 more of them throughout the plant. We are now operating virtually without loss of time so far as bearing trouble is concerned.

In addition we have this type of lubricator connected with Westinghouse mill type motors. In the old days we had constant trouble because of oil splashing out of oil well bearings and saturating the armature coils and field coils, causing a short circuit, and necessitating rewinding of armature and coils. But with our new-style lubricator all these difficulties have been done away with. Another place where we have solved a problem is with our scrap or alligator shears. Formerly the men poured oil all over the outside of the bearings, but very little reached the right place. Now the lubricator takes care of this, distributing grease to the parts that need lubrication most.

Many of us make the mistake of worrying too much about initial cost in considering new equipment of this sort. I suppose at our plant we are no different than others in such matters and that we did a large amount of hesitating before we decided to go ahead with this lubricating proposition. But I have just looked up the figures and in the light of our experience I feel that we made a cheap investment.

Take the 8-lb. manifold safety lubricator installation on our 10-ton, 85-ft. span crane, for example. The lubricator itself cost $60, although the price may be somewhat higher now than it was two years ago, when the installation was made. The equipment consisted, first, of 100 feet of 1½-in. pipe run the length of the bridge and across its ends. This pipe cost 21 cents a foot or $21, the biggest item of the equipment cost; it has 18 outlets reduced from 1½ in. to ½ in.

In addition there were 18 stopcocks at 70 cents each, 18 tees 1½x1½x½ in. at 17 cents each, 300 ft. of ½ in. black pipe at 11 cents a foot and 36 unions ½ in. size at 15 cents each—a total for equipment of $45.36.

Lubrication equipment for the trolley of the crane was provided by running lines separately to 16 bearings. For this it was necessary to use 120 ft. of ½-in. pipe at 11 cents per foot, 16 stopcocks at 70 cents each, 16 unions at 15 cents each—a total of $26.80.

The actual task of installing the lubricator and its equipment required the services of four men receiving 66 cents an hour for a trifle less than two full days. The charge for labor was entered as $42.24. The total cost of lubrication, equipment and installation on both crane and trolley was $174.40.

Obviously we no longer have accidents from lubricating. There is one central point of lubricant distribution, with many bearings lubricated from one central point. Pipe lines lead from the manifolds to each bearing and the lubricating grease is forced into each bearing under high pressure. Many of the bearings lubricated under this system are as much as 100 feet away from the point of distribution, but never-

theless the results are perfect. The lubricator and the manifolds are at all times stationed in a safe place, so that our employes never need take chances on their safety. We have no accidents.

Iron pipe, brass tubing and armored flexible metallic tubing runs from the lubricator to the bearings, and when the very best petroleum grease is used there is no possible chance of the pipe lines becoming stopped up, because in high grade grease there is no filler present to become separated from the oil.

All of us feel now that our worries in regard to lubrication are over.

The Economies of Electric Heat in Metallurgical Processes

By DWIGHT D. MILLER*

IN the experience of the writer during his eight years of missionary work involving the introduction of electric heat in metallurgical and various other industrial processes, he has encountered a decided tendency of resistance to any innovations or change in existing practices.

This inclination was most marked in the early or pioneer days and immediately a host of objections and reasons why it could not be done economically were offered and even insisted upon. There seemed to be a wall of inertia surrounding the management which had to be broken down before even an intelligent discussion of the possible economics which might reasonably be expected, could be had.

In many cases today, even in the face of the tremendous expansion of the use of electrically generated heat; in spite of the fact that there are a great number of successful installations in divers fields of applications and that this field is daily expanding; in spite of the fact that the use of electric heat has become practically standardized in some of the process because of the fact that it has established itself there by the actual economies effected by its use, this tendency still exists, although of course, to no such marked degree.

Chief among the objections is the "bugaboo" of high cost of heat. I use the word "bug-a-boo" advisedly because it is the object of this paper to demonstrate that such an objection is nothing more than that.

In a paper entitled "The Electric Furnace as a Medium for Heating Non-Ferrous Metals" read in Boston about seven years ago before the American Institute of Metals, the writer made the following statements: "Since it is an established fact that the cost of a B.t.u. produced from electric energy is many times greater in almost every instance than that produced by the combustion of fuels commonly used in metallurgical industries, the question naturally arises how can the electric furnace compete with and not only maintain its position but even replace other types of furnaces under such a handicap."

"The answer is simple, in fact the only one that will stand the 'acid test' of modern up-to-date business practices—the use of electricity has many advantages which offset the handicap of the higher first cost per B.t.u. produced."

"The crux of the whole matter lies in the fact that the cost of heat alone as compared with the cost of the entire finished product is in many instances negligible. Many items enter into the total cost of production of which heat energy is only one, so that while electric heat may be more expensive still, if by its use other items (such as time required, space, labor, fire insurance, etc.), are cut in greater proportion, producing greater quantity as well as improved quality, it is evident that not only is electrically generated heat cheaper to use but also its use is imperative in order to compete successfully with those using it in similar processes."

The situation of the manufacturer today is simply this: Under his present methods of manufacture he is producing a certain quantity of a given quality so that when contemplating a change, his main consideration should be—will the use of electric heat give greater quantity or improved quality or both for the same overall cost of finished product or the same quantity and quality for a less overall cost of finished product. If electric heat will produce either of these conditions its use is most assuredly a paying proposition.

Executives are prone to lay altogether too much stress on the first cost of electric heat. Much more than it warrants. Most material passes through a dozen or more operations before it emerges as a finished product, but the executive is apt to look only at the one item of B.t.u. cost and jump to the conclusion that because this item is higher than what he is now paying for fuel that necessarily the cost of the entire process will be increased in proportion, instead of making an analysis of the different steps of the process through which the material passes and determining what reduction in costs of the other items constituting the total cost of the finished product that the use of more expensive form of heat will effect

In this manner, and in this manner only can an intelligent conclusion be arrived at as to whether the use of electric heat is an economical and paying investment.

There are a great many processes in which it would be foolish to attempt to use electric heat. Again there are methods of manufacture in which it is hopeless to attempt to show any savings with electric heat because of the present operating conditions but which would show a handsome saving were these present conditions changed. Here I have in mind intermittent operation of a few hours a day or a few days per week as against eight to 10 hours daily operation or the ideal condition of continuous 24 hour operation. In other words, snap-shot judgments are always danger-

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ous; particularly so when considering the use of electric heat.

In general, it can be said that in those processes in which the major cost item is that of heat and their nature such that neither the quantity can be increased nor quality improved, it were best to leave electric heat alone. In fact, no well informed heating engineer would recommend its use in such circumstances.

Unfortunately there have been and probably still will be some ill-advised installations of electric heating mediums with the result that the industry as a whole suffers therefrom since such news travels quickly and is widely disseminated. Personally, the writer can frankly say that he has turned down at least 60 per cent of the proposed installations on which his advice has been sought during his activities in the industrial heating field from Maine to Missouri.

In the high temperature application of the iron and steel industries the question is entirely a metallurgical one. Sufficient heat can be generated and utilized from a choice of four or five fuels as sources and it is the effect that the particuiar form of heat will have on the materials being processed, with which the manufacturer and his metallurgist is mainly concerned. In other words, furnaces, both melting and heat treating, ovens and the other various heating mediums should be offered solely as an agent for securing certain definite metallurgical or physical results and not at all from the standpoint of a piece of electrical apparatus.

This calls for and requires at least a broad general knowledge on the part of the salesman of the process together with the chemical reactions and physical characteristics involved.

So much for general statements. Let us now consider the subject concretely and analize it, carrying the analysis through logically from the generation, utilization and control of electric heat, as compared to other sources, to its application and results secured thereby.

A table is here given showing approximate comparative costs covering the generation (or B.t.u.) costs of the four fuels mainly used in industrial processes.

Source of Heat	Cost per Unit of Combustible	B.T.U. per Unit	B.T.U. for 1 Cent	Cost Ratio
Coal	$6.00 per ton	12.500 per lb.	41,667	18.3
Fuel Oil	5c per gallon at burner	140,000 per gal.	23,333	10.2
Natural Gas	50c per M cu. ft.	1100 per cu. ft.	22,000	9.6
City Gas	75c per M cu. ft.	525 per cu. ft.	7,000	3.1
Electricity	1½c per K.w.h.	3412 per K.w.h.	2,275	1

These cost ratios are purely theoretic and are based upon the assumption of perfect combustion. It is well known and recognized by practical men that these theoretic heating values are seldom if ever attained in commercial practice. If 75 per cent of the above heating value of the various fuels given is realized it is considered excellent practice, since 60 per cent to 65 per cent is the more prevalent.

It is right there that electricity offers its first advantage that ultimately more than offsets its higher first cost, viz; it is changed into heat at 100 per cent efficiency regardless of temperature.

Hence, assuming the higher value for combustion heating these B.t.u. cost ratios for fuel are reduced 25 per cent and electric heat has made its first gain.

In other words, the practical cost ratios in favor of fuel now become:

Coal	13.7
Fuel Oil	7.7
Natural Gas	7.2
City Gas	2.3
Electricity	1

Thus, after the process of generation of heat only electric heat still is handicapped in approximately the above ratio.

The next step to be examined is the utilization of the heat after it has been generated and here again electricity makes further large gains to offset the above handicap.

Recognizing as they must that electric heat is the most expensive of any, the manufacturers of apparatus in which it is used have so designed it that the efficiency of utilization is far in excess of that of similar devices and apparatus depending upon combustion of fuel for the heating medium. Again the character of the process itself employed with combustion heating is such that it is inherently and necessarily much less efficient than where electric heat is used. For instance, compare the practice of crucible melting with fuel as against that of melting in the arc or inductive furnace. In the one case heat is generated on the outside of the crucible and must be conducted through the material of which the crucibles are made before it can even begin to perform the function for which it is generated, viz; the melting of metal which ultimately is accomplished at an efficiency varying from 1½ per cent to possibly 3 per cent while in the other case the heat is generated and applied within the enclosure itself and directly to the metal at an efficiency from 65 per cent to 85 per cent. Thus it is at once evident that in this particular comparison of crucible melting as against electric melting of steel that electric heat has the advantage on a strictly B.t.u. basis to say nothing of the other advantages accruing from its use.

The late Prof. J. W. Richards in his Metallurgical Calculations Part 1, p. 89, gives the following efficiencies for the various methods of melting steel.

	Method	Efficiency
1.	Crucible steel furnaces fired with coke	2%— 3%
2.	Reverberatory furnaces for melting metals	10 —15
3.	Regenerative Open Hearth Steel Furnaces	20 —30
4.	Shaft furnaces — Foundry cupolas	30 —50
5.	Large electric furnaces	60 —85

While H. W. Gillett of the Bureau of Mines, Bulletin No. 73 "Brass Furnace Practice in the United States" gives as the result of an investigation covering more than 300 foundries an efficiency ranging from 1½ per cent to 16 per cent according to the type of melting medium employed with a general average of 7 per cent in this lower temperature field.

The term furnace efficiency as used above is readily determined by the formula:

$$\frac{\text{Heat usefully applied}}{\text{Total heat supplied}} = \text{Furnace Efficiency}$$

The nearer these two factors become the greater the efficiency obtained with the limiting possibility that all of the heat supplied is usefully applied, in which case we obtain 100 per cent efficiency. However, since no means have as yet been found of doing away with all of the losses in any of the various processes involving the utilization of heat, this fraction is always less than unity.

A further examination of the above formula readily reveals why it is that we get so much greater efficiency from well designed electric heating mediums than we do from those heated by combustion. It is evident that the total heat supplied equals heat usefully applied plus heat lost and it is this last factor that controls the efficiency of the apparatus in question.

Now, the sources of heat loss are three, viz; radiation, conduction and convection, and it is because the source of heat loss due to convection is eliminated in the processes of melting and general heat treatment by electricity that the higher efficiencies are secured and maintained, while on the other hand convection losses are necessarily present whenever heat is generated by means of combustion; moreover this source of loss is, in general, the greatest of the three.

Electric apparatus for melting and general heat treatment is designed and constructed as nearly air tight as possible, the heating effect being obtained by radiation of the heat from the heating medium (carbon or graphite electrodes or metallic heating elements) to the metal and through the metal itself by conduction while in combustion heating convection is inherent to the process the heating effect being obtained by all three methods.

From what has gone before it is now evident that electric heat already is less expensive to use than those fuel fired processes showing the lower efficiency ratios given in the table. When it comes to the more efficient processes we must look to the many advantages secured from the use of electric heat to offset its still higher first cost.

Among its more prominent advantages are the following:

1. It can be controlled automatically and with a degree of nicety impossible to attain with any form of combustion heating.
2. It can be utilized in any atmosphere, oxidizing, neutral, reducing or even in a vacuum.
3. It can be generated in any quantity regardless of temperature and confined to a definite area.
4. It has practically doubled the temperature range above zero, making possible the manufacture of materials heretofore unattainable and opened up new processes, particularly in the electrochemical field.
5. By its use greater quantity as well as higher quality can be produced.
6. Due to nicety of control the product is more uniform and results duplicated day after day.
7. By its use rejects are reduced to a minimum with the consequent saving of duplicate treatment.
8. It is clean, sanitary and safe.
9. It saves time, labor and space with the attending saving in overhead, real estate and taxes.
10. By its use the fire hazard is greatly reduced, together with the risk of loss of material, product and even life itself.
11. Greater thermal efficiency in that it is transformed into heat at 100 per cent efficiency and utilized at from 2 to 30 times the efficiency possible to obtain from combustion heating.
12. It is more flexible and can be applied more conveniently to a large variety of uses.
13. By its use large heat radiation, obnoxious fumes, dirt and noise are eliminated and the working conditions of labor vastly improved.
14. By its use we obtain practically laboratory accuracy on a tonnage basis.

Of the above advantages that listed first, viz., "Control", is in the opinion of the writer the most important since from it most of the other advantages naturally follow.

In all metallurgical processes the three vital factors which enter are temperature, atmosphere and time. We obtain closer control of these factors through electric than we do through combustion heating mediums both because of the different manner in which the heat is generated as well as utilized in the medium itself.

Let us consider these factors in the order named, taking up that of temperature first.

In any given electric furnace the resistance of the heating medium is fixed, be it carbon, graphite or metal. The voltage of the supply line is also fixed, hence the same current must flow "per se" according to the law governing the flow of current. We have no choice, no option since it is an unchanging and moreover an exact law so that we get the identical current or wattage for a fixed, given condition automatically day in and day out. Now wattage in this case is temperature and does not vary for the fixed condition we have assumed as in the case of a furnace already built. Moreover in the case of the electric furnace we have the additional advantage of being able to vary the temperature at will either up or down by varying the input of power. This is accomplished most easily by varying the voltage by means of taps in the transformer and by providing a large number of taps, the temperature variations can be made in very finely graded steps. Carrying out this idea still further in the case of metallic heating mediums the heating elements can be divided into sections and each section controlled by smaller transformers, with several taps and the elements so placed that the work is completely surrounded by them from top, bottom, both sides and both ends giving absolute temperature uniformity and heating effect.

All this is possible since electric heat is not the result of the chemical process of combustion but merely another form of electrical energy itself and secured at 100 per cent efficiency by merely throwing a switch.

On the other hand heat from fuel is dependant upon the chemical process of combustion with oxygen and to have oxygen we must have air. Air is a mechanical mixture of oxygen and nitrogen in which the nitrogen is present both by weight and volume in the ratio of approximately 4 to 1. While it is present in this large ratio nitrogen is inert and of no value whatsoever in the process of combustion, in fact it is a great detriment since all this extra weight must be heated up and space provided for the excess volume. This is one of the reasons why combustion heating is inherently less efficient than electric heating. It must be remembered that solid or liquid fuel must be converted into gas and mixed with a certain minimum quantity of the oxygen of the air before combustion can take place, and in order to get perfect combustion this air must be mixed in just the right proportion, a condition most difficult to control or maintain and seldom if ever fulfilled in commercial practice as already pointed out above.

Again no two shipments of coal or oil will have the same B.t.u. value under laboratory test while that of gas both natural and artificial will vary from day to day, especially in cold weather. It is thus apparant that if we start with a variation in the calorific value

of the fuel itself, it is hopeless to expect the same uniformity from combustion heating as we get from electric heat which is regulated automatically by the unchanging law governing the flow of current.

This, however, is not all since combustion heating is dependent also on variables beyond human control such as velocity of wind and humidity of the air. These affect the draft and consequently the volume of waste gases that can be handled through the furnace and up the stack. Again, the velocity of the gases under high air pressure may reach cyclonic force and the path of these gases confined to narrow and well defined area so that a thermocouple placed in the path of the gases will register hundreds of degree temperature difference than when moved but two or three inches so as to bring it on either side of such paths. In other words, we do not get the same uniform and even temperature distribution that we do in the electric furnace where the work is competely surrounded by the heating elements. This naturally follows also from the fact that usually there are two or more burners spaced along the side of a heat treating furnace so that there is bound to be cold spots in the areas between the burners while in the electric furnace the heating elements can be uniformly distributed over the entire area of the enclosure.

Coming next to the question of atmosphere this is again more readily controlled in the electric heating medium since in this case as already explained, the process of comustion is not involved. The atmosphere in the case of metallic resistor heating elements is normally practically neutral, possibly slightly oxidizing, but can be made heavily so that introducing air or distinctly reducing by introducing a small amount of oil or charcoal according to the requirements of the process, the oil or charcoal giving off the CO gas required for a reducing atmospheric condition. In the case of carbon or graphite electrode furnaces as well as those using broken carbon as the resistor element the atmosphere is normally slightly reducing but again can be varied at will. Thus the question of scale formation is reduced to a minimum and another item of saving credit to the electric heating.

With combustion heating the atmosphere is necessarily a strongly oxidizing one which results in heavy oxidation of the product. True this can be greatly reduced by using muffles or by burning an excess of fuel but in either case, only at the expense of a greatly reduced efficiency. The B.t.u. value of CO_2 is 14,000 B.t.u. and that of CO, 4,450 B.t.u. so if we reduce the air supply using an excess of the fuel so as to get only partial combustion it is done with the loss of 10,150 B.t.u. per lb. of carbon. Again, fuel during the process of combustion gives off various products which have a deleterious effect on the material under treatment. Principally among these is sulphur and its compounds which is readily absorbed by the hot or molten surface of the metal and results in additional expensive treatment to eliminate it. We also have accluded gas and "wild" metal to which reducing agents must be added in order to produce the quality desired. This again adds expense and again electric heat is credited with a saving item.

The question of time, the remaining factor, to be considered is of great importance since it involves the question of production as well as quality. From what has gone before when considering "control" a great deal of argument is not necessary to demonstrate that here again electric heat has the advantage. With a given weight of metal having a given chemical analysis hence a fixed specific heat, it must be evident that if we apply exactly the same quantity of B.t.u. at the necessary temperature that the charge will melt or become thoroughly soaked in the same time heat after heat. While on the other hand if we apply a varying B.t.u. with a varying temperature the time for completing the process will naturally vary from heat to heat. In the case of electric heat the former condition exists while with combustion heating we have the latter condition. In fact, it has been demonstrated time after time that after an electric furnace has been installed and sufficient time has elapsed to break in the operating crew and standardize the process, that the furnace can actually be run on a time schedule and, barring accidents or delays from outside causes, will maintain such a time schedule extremely close day after day. This means increased production and higher quality. Electric heat again scoring two more items of saving.

From what has gone before, the basic difference between well designed electric and combustion furnaces under equally competent operation must now be most evident. In the first case we are dealing with an apparatus of precision operating under known and fixed conditions which lend themselves readily to close and automatic control, thus doing away with the variables always present when human control must be depended upon. On the other hand when combustion heating is used many variables in addition to that of the human element, must necessarily enter since they are inherent to this method of heat generation and utilization.

To attempt to follow through in like manner with all the advantages listed above in favor of electric heat would make this paper altogether too long. Suffice it to say that in any well chosen application these advantages far outstrip the higher B.t.u. costs as well as higher first cost of apparatus, including interest and depreciation in every case and show a handsome return on the investment.

Before turning to various actual applications and showing how the claimed advantages are unquestionably secured in every day commercial practice, I want to touch upon the subject of improved working conditions of labor and labor turnover.

Much has been written within the past few years on "Human Engineering". The subject has attained great prominence among the progressive executives and justly so. Even though a workman may be known by a number only he is still a human being and entitled to enjoy the very best working conditions that the particular trade in which he is employed can provide. The problem of labor and labor turnover is vital to any industry and really the most expensive if not solved right since upon it success or failure of industry as a whole is dependent.

It is a most serious condition to have an old experienced and well broken in man or crew whose "Esprit de Corps" has been built up so that they work in thorough harmony with the management, be compelled to leave due to the severe conditions under which they are obliged to work. It means a large loss both in material, time and quality while breaking in the new crew and an executive is justified in going to any reasonable length in order to prevent such a condition.

There is no question but that electric heat, with its absence of large heat radiation, obnoxious fumes, smoke, dirt and noise produces far superior working conditions for labor. In fact, cases are on record where labor having once worked in plants using electric furnaces have refused to accept employment under combustion conditions unless compelled to do so by actual necessity.

"It is an ill wind that blows nobody any good" and the great world war has helped measurably in demonstrating the economies of electric heating applications. Many plants installed electric furnaces by directions of the Government which otherwise would probably not have done so, at least at that particular time. However, having once operated them and experienced the increased production, improved qualities and economies effected by their use they have carried that lesson over into peace times. True, a large number were shut down, sold or abandoned altogether, but that was in almost every instances because the particular work for which they were installed to perform had ceased with the ending of the war and not because of the failure of the furnace to turn out such work economically.

The microscope, the thermo-couple, and pyrometer have heretofore been the instruments which have lifted the metallurgical industry out of the rule-of-thumb stage and placed it on a scientific and exact plane. However, we are moving very fast these days and with the coming use of the X-ray and continued research the standards are being contiually raised. What is more this knowledge is being disseminated and absorbed daily so that there is bound to be a radical change in specifications and in the manner in which material is bought. Already most marked changes have been made in the buying of steel and its alloys according to the latest specifications but there are still vast fields practically untouched as yet in this respect in which the electric furnace has already established itself or bids fair to do so in the very near future. I refer to the Iron Industry with its alloys which are already beginning to appear—to the brass industry—to the great malleable iron field and it is because of the superior characteristics, both physical and chemical that can be secured by electric heat that will force buying on as close specifications in these fields as in the steel trade. It is merely a question of time, a question of realization on the part of the buying public that superior grades in these industries can be produced by means of the electric furnace before the product will be bought on just as close and exacting specifications as now obtained in the steel industry. Then the manufacturers producing a higher quality iron or brass will not only be able to demand but actually receive a higher price than one putting out an inferior product. "A word to the wise is sufficient".

Now let us take a few concrete outstanding examples of metallurgical processes and compare them as to results obtained and economies effected by the use of electric and combustion heating. Consider the melting of iron in a cupola as against an electric furnace melt, the product being a high grade low sulphur grey iron. Because of the nature of the melting medium in the case of the cupola high grade, high priced pig and melting scrap must be used and in such proportions as to give the required chemical analysis of finished product. The average cost of producing such a product in 1922 in Cincinnati was between $35 and $40 per ton of molten metal at the spout, while a higher grade grey iron can be produced in the electric furnace for $10.00 less cost per ton of metal at the spout. If the output is 20 tons per day this means a saving of $200.00 per day or approximately $60,000 per year of 300 days. On this basis the electric furnace with interest and depreciation added would pay for itself in approximately eight months.

As to the process itself, in the case of the cupola the charge is built up in the usual way, the fire started and the blast turned on. As soon as the metal begins to come down it comes first of all into a heavily oxidizing zone which greatly increases the melting loss and does not improve the metal. As the coke burns it gives off sulphur which is readily absorbed by the metal which again does it no good and finally the metal picks up foreign matter from the slag which helps its further deterioration. Nor is there any help from this, since the metal cannot be purified or altered in any way to meet the required specification but must be poured as it comes down, and if not up to specifications must be pigged or poured off for remelting. Again there is no way of superheating the metal when melted in the cupola and as there is a large drop in temperature when pouring into the laddle and from the laddle to the moulds, cold metal is often encountered during the last part of the pour with the consequent increased spoilage of castings. The distance the metal has to be transported from the cupola to the pouring floor also has an important bearing on the temperature available at which the castings can be poured.

Now contrast this with an electric furnace melt. In this case a much cheaper grade of scrap can be used mixed with borings or in some cases all borings may make up the charge which is actually being done today and has been for the past year. True on a purely conversion cost basis only the cupola will be found in almost every instance to have a large margin of saving, yet this is more than offset because of the cheaper raw material it is possible to use with electric furnace practice. With pig costing around $32.00 to $35.00 per ton as was the case in the Cincinnati distrct when the figures above cited were compiled, an electric charge can be made up for less than half of this cost per ton, so that even though the conversion cost with the electric furnace is double that for the cupola there still remains at least $10.00 per ton saving in favor of the electric process.

The reason for better iron from cheaper scrap charged into the electric furnace is because in this case we have complete control of the entire melt. The metal is charged into the furnace enclosure—is not subjected to any oxidation, hence the melting loss is much reduced. Since there is no combustion there are no sulphur fumes to contaminate the melt and the gates and risers can be used over and over again. This is not the case with cupola melting since the sulphur content in the metal builds up each time it is used and soon becomes unfit for further use.

Furthermore, in an electric melt as soon as the charge has become molten, spoon tests can be taken and test made both as to its chemical composition as well as temperature and when using the basic process the charge can be brought to the exact specifications desired by manipulating the character of the slag and the addition of alloys. The metal can also

be superheated to any desired degree before pouring so that hot metal is always available for pouring small intricate castings. Straight acid melting in the electric furnace in the majority of steel foundries is the prevalent since it turns out a high grade, uniform product and is less expensive than the basic process which is resorted to in those cases requiring special treatment.

Another use of the electric furnace is that of duplexing with the cupola in the foundry. In the case of a jobbing foundry making various grades of iron, the entire melt from cold can be made in the cupola and that part of the tonnage which must meet the more exacting specifications charged hot into the electric furnace and finished as required. This process of duplexing requires a much less current consumption and avoids the necessity of shutting down the cupola.

I have purposely avoided making use of any definite figures in the above comparison because figures will always vary according to the location of the plant and conditions under which the melt must be made. Figures compiled for a given month at a given locality while true for the particular practice under consideration will not necessarily be true or of much value for another proposed installation in a different section of the country since the market price of raw materials fluctuate as well as the power rate according to location. Each installation is distinctly an engineering problem and must stand or fail upon the analysis of conditions existing in the locality where the installation is to be made. In other words, geography has much to do with the matter.

The main object in drawing the comparison was to point out the large reserve the electric furnace has in the matter of material charged to offset the higher first cost of power for heating purposes; also the high grade product secured by its use as well as its flexibility of operation.

The subject of heat treatment is probably as broad a one as there is in the entire metallurgical field since under it are included hardening, annealing, and drawing or tempering. Moreover, more progress in this field has been made in recent years than in others because of the constant research and investigation which has been carried on so that modern specifications in this field have stiffened considerably and are most exacting. As stated above, the public knowing that certain super-steels can and are being produced are not content with anything less. These exacting requirements can be met with greater certainty and duplication of results by the use of electric furnace in that from the nature of the apparatus used we eliminate variables, deal with fixed and known quantities over which we have complete and automatic control.

Take for instance the process of annealing. From the chemical composition of the charge we know from tests and research already made between just what limits of temperature the material should be heated. It is a cardinal principle of heat treatment that once having determined the temperature at which the material should be treated to yield the best results, to work at that temperature within as narrow limits as possible. To work much beyond the critical means grain enlargement and waste of fuel or power while if the critical temperature is not attained the physical properties desired are not secured. As already explained, due to the manner in which the charge is completely surrounded by the heating elements in a properly designed electric furnace as well as the close and automatic control of temperature, we can work within closer temperature limits in the entire furnace chamber than we can with combustion heating since there is better distribution and greater uniformity in the former than in the latter. In combustion heating there is a general tendency to overshoot. By that I mean that in order to be sure that the work is at the right temperature, a temperature anywhere from 50 to 100 deg. F. higher than necessary is maintained with the consequent grain enlargement of the steel, making it inferior in quality. Again the temperature gradient between the source of heat and the work is higher in the combustion than in the electric furnace and there is considerably less danger of the work being burned when heating for hardening.

Electric furnaces are much more heavily insulated than are combustion furnaces, hold the heat at a greatly increased efficiency and are as near air tight as possible. This means that what scaling takes place is at a minimum and generally takes place outside of rather than within the furnace. In fact, there are a number of cases where bright annealing is done in the electric furnace with no scale formation. This question of scale is a serious one, especially when working on a very close margin for finished product. The writer has in mind one installation where the tolerance was .004 of an inch which meant no scaling was allowable. To remove scale is costly both in labor and material and slows up production.

As to time of soak and means of determining when it has taken place so that the temperature is uniform throughout the piece, here again we have automatic indications of such conditions in an electric furnace. The graphic recording meter which actually shows a hump as the critical is attained, known as the "hump method" is one, while the use of two thermo-couples in conjunction with recording pyrometers is another method commonly in use. In this case one thermo-couple is set to record the temperature of the heating element while the other is in contact with the work. When the cold charge is placed in the heating chamber which has first been brought to temperature while empty, the temperature of the entire enclosure naturally falls, since the cold work absorbs heat very fast and there will be a wide difference or temperature head between the curve recording the heating element temperature and that recording that of the work. As the work heats up these two curves come nearer to each other, that on the heating element always indicating the higher temperature while that on the work continually climbing towards it. Now when these two curves become parallel it is a true indication that the work is at a uniform temperature throughout, because if there was still a transfer of heat from the surface to the interior of the piece or charge by conduction, the curves would not remain parallel. The fact that they do remain parallel shows conclusively that there is no further transmission of heat by radiation from the source to the work, hence no loss of heat from the surface to the interior of the piece or charge.

The temperature difference between the parallel curves of the two instruments at the end of the period indicates the temperature head or drop between the heating element and the work. In the latest types of furnaces this is comparatively small, since with

distribution of the elements over the entire enclosure the wattage per square inch of heating surface is greatly reduced.

Another feature that effects a saving in the process can be noticed from the curve recording the temperature of the heating element. Automatic pyrometers are available which will control within ¼ of 1 per cent so that having set the pyrometer on the heating element to that temperature which it is desired to maintain, it will do so automatically within the close range just stated. This in turn regulates the power input to just the exact quantity required. In other words as soon as the element temperature exceeds by ¼ of 1 per cent that at which its controlling pyrometer has been set to work, the power is automatically cut off and when it drops ¼ of 1 per cent below the set temperature, the power is automatically cut in again. This saves much power and is plainly indicated by the form of the curve on the pyrometer. It is evident that if a mass is not heated uniformly it will not cool uniformly, hence there will be trouble in all the subsequent operations through which the piece must pass. It means inferior product and a greater percentage of rejects.

It is possible to continue with this same kind of analysis through the entire range of metallurgical process. For instance, in the brass field the electric furnace occupies an especially strong position since it is the means of reducing to a minimum probably the most wasteful factor in that industry, one which does not enter, however, into the ferrous field, viz: metal loss due to the volatization of zinc which escapes in the form of oxide in excessive quantities because of the nature of the melting medium used and the high temperature employed without compensating features.

However, it is believed that enough has been said to amply demonstrate that we can and do approach practically laboratory accuracy on a tonnage basis by the installation of electric furnaces after a complete and competent analysis of existing conditions as well as conditions to be met has been made and found to warrant it, and that under such circumstances such an investment will show a handsome profit on the complete cost of the finished product.

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*A. I. & S. E. E. General Specifications for Construction and Installation of Automatic Engine Stops**

THESE specifications shall be known as the "Association of Iron and Steel Electrical Engineers' Specifications." It is intended they will apply to all automatic engine stops of whatever kind or method, insofar as they or any part of them may be applicable.

Automatic Quick Closing Valves.

For steam pressure above 150 pounds extra heavy valves should be used. Preferably they should be of steel on account of shock, high pressure and high temperature.

A combination stop and throttle should not be employed where the steam line is over 3½ inches in diameter.

For condensing steam engines and for turbines, vacuum breakers should be used and operated in conjunction with the stop valve.

Valves should be of full working capacity to insure minimum pressure loss, at the same time should not be so large that leakage past clearances will operate engine without load at full speed.

Drawings showing full directions for installing and wiring should be furnished by the manufacturer.

So far as possible the use of fibrous packing, or packing composed wholly or in part of organic matter, should be avoided. Metallic packing should be used wherever practicable.

Stems that must be packed to prevent leakage of steam, preferably should extend in or above a horizontal line.

Where an automatic valve is constructed with a by-pass for equalizing pressure on both sides in order to reset it, the valve in the by-pass should be of such make that it cannot remain in the position that would prevent the main valve from operating after the attendant had released his hold on the by-pass valve.

Electrical Equipment.

Current. Where high tension direct current 110 to 220 volts is available, current should be supplied by generators in addition to current furnished by storage batteries. The batteries should be of sufficient capacity to deliver necessary current during the interruption of main source of supply for any period that is likely to occur. The number of cells should be so proportioned to the resistance that they will float on the line when fully charged. Battery should be placed in a clean cool place easy of access. Preferably one battery of sufficient capacity for all engine stops in a plant should be provided.

Switches. Switches and contacts for opening the circuit should break on both sides of the line, in order to prevent the current from being maintained through a ground on one line. Where engines or turbines are connected to generators, a holding or knock-out coil on the circuit breaker should be placed in series with the stop circuit, or a separate circuit should be provided to trip the breaker when the automatic stop operates.

Stop stations. Switches at stop stations must be of the type for manual operation. They should be enclosed in dust proof cases having glass in the covers that can be broken to operate the switch. The cover should be supplied with a lock so that the case cannot

*Adopted as the A. I. & S. E. E. Standard September 24, 1923.

*The enormous demand for copies of these specifications necessitates this reprinting.

be opened unless for the purpose of renewing glass, or for making tests without breaking the glass.

Switch boards. The panels should be slate and not less than one inch thick, or of other insulating material. Mounted on the switch board, for closed circuit system, should be a voltmeter, ammeter, charging instrument, adjustable resistance and dial switch so arranged that the charging rate of battery may be varied at will; a main switch and as many circuit switches as may be required; an automatic reverse current circuit breaker so arranged that, in event the voltage drops or fails entirely, it will automatically disconnect the battery from the generator and will, as soon as the voltage is restored, again connect the battery and generator.

Wiring. The wiring should be double throughout extending to the tripping apparatus and vacuum breaker, if there is one. In case wires are extended for more closers the wires should be opened, extended to the new closers and back in the line again that all circuit breakers or closers may be included. Wires should never be shunted to other wires.

Test board. For an open circuit system a test board should be supplied, containing the necessary equipment for making tests. The wires should be so arranged that tests can be made to prove that all are intact including wiring to the coil itself without tripping the stop. The switch for this purpose must be held normally in position by spring tension, so that it is impossible to leave it in the testing position.

Tripping Devices.

Governors. Where a fly-ball governor with belt drive is used for the initial requirement in bringing an automatic stop into operation, it may be of the horizontal or of the vertical type, that is, the spindle may be horizontal or vertical.

Belting. The governor should be driven by multiple rope drive to insure positive operation even though all but one of the ropes should fail. Each rope should be amply strong to perform the work required of all.

Pulleys. The pulleys should be grooved and should be proportioned for normal speed. If a flat belt is used the pulleys should be flanged on both sides. Where more than one flat belt is used they should travel on separate pulleys.

Adjustment. The governor should be so adjusted it will by performing some office, like breaking or closing a circuit, tripping a latch, etc., bring some auxiliary part into operation, which in turn will cause the automatic valve to close when the engine reaches the maximum limit of speed required for tripping, which should be approximately 10 per cent in excess of normal.

Horizontal governors. A governor of the horizontal type should have an idle arm and pulley attachment, with the pulley riding on the belt so that should all the belts break or come off, the arm will swing down and open or close the circuit, as the case may require, through the medium of suitable attachments.

Vertical governors. A governor of the vertical type should be provided with an idle arm and pulley attachment with the pulley riding on the belt as described for horizontal governors, or it may be so constructed the belt will, by its tension, hold the pulley shaft of the driven pulley on a line that is at right angles with the line of travel of the belt, and so that if the belt breaks or comes off the vertical spindle will revolve sufficiently to make or break the electric circuit, through the medium of suitable attachments, as may be required by the system employed.

Motion rectifiers. If a governor is used for bringing the stop into action on a reversing engine, a motion rectifier should be provided for converting alternating rotary motion, as produced by reversing blooming engines, into motion of one direction, to prevent its going into action due to sudden reversal at or below normal speed.

Steam operated governors. The same general arrangement prescribed for breaking electric circuits or tripping mechanical devices should be followed, so far as belt drive is concerned, in the installaton of steam operated governors. Valve stations for bringing the emergency valve into operation should be located not more than 30 feet distant from the stop valve.

Pins projected by centrifugal force. Where a pin, that is projected by centrifugal force for operating a tripping device, is pocketed in the rim of a fly-wheel, a crank pin disc or a counterbalancing sector, or a yoke on an engine shaft—the yoke being specially provided for holding a pin—the pin and pocket should be machined for an easy fit, but not too loose. If a compression spring is used the spring should be of such diameter it will not bind in the pocket when reduced in length by its utmost compression, and the coils should be so open that the utmost compression required will not bring them in contact with each other.

Standardization of Engine Stops

By WALTER GREENWOOD†

WE have various kinds of control equipment that have been recommended as perfectly reliable for automatic operation, yet some persons are so skeptical concerning them that they place greatest reliance on attendants who are supposed to be careful. The frequent failure of all kinds of automatic limit devices, such as engine stops, hoist and travel limits that were considered perfectly reliable, furnishes excuse for skepticism in those who have not given much attention to their construction and installation. To those who have given much thought to the subject it is plain that correct construction, installation and methods of operation would, if practiced, prevent failures. If this is true, standards that tests and experience have shown to be reliable, should be provided, and it should be the duty of associations formed for the advancement of ideas that interest industries, to

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agree upon such standards and bring them to the attention of those interested.

There seems to be a general call for such standardization of equipment as is necessary for efficiency and safety, particularly safety, and it seems as though the A. of I. & S. E. E. could serve no higher purpose than to continue and press the work of its Standardization Committee.

We are attempting to present some argument which we hope will be convincing, in favor of standardization, in this discussion of automatic engine stops.

None but those who are constantly employed in the work of analyzing the conditions that surround accidents, can fully realize the importance of standardization in the features belonging to equipment in order to avoid accidents. In studying the requirements for general specifications for construction, installation and safe methods for operating engine stops, such construction and methods only have been considered as obviously are important, and the lack of some one of which was responsible for every fly-wheel and almost every turbine explosion that ever occurred.

Speed regulators (governors) almost justify our confidence in them as also do good attendants, but history tells us they often fail. Generally their failure is occasioned by contributary causes other than imperfect construction or lack of good attention. The office of a speed regulator is to control speed to suit load conditions and, of course, to prevent over-speeding. The office of an automatic engine stop is to guard the speed regulator and act when it fails, or when the attendant does not or cannot act promptly, either of which failures can and does occur.

In looking over the literature on automatic engine stops, furnished by manufacturers, we find that every contingency that might arise and cause an engine or turbine to over-speed has been considered, and advice has been given by them concerning the making of all kinds of installations. In looking over the installations that have been made, we find too many cases where important advice and necessary requirements have been neglected.

In looking over the records of fly-wheel and turbine explosions we find the reason why the suggestions herein contained should be complied with. We recall a case where an engine driving a generator would overspeed and trip the automatic stop valve. The interruption it caused was serious. The department head in charge of the engine insisted the control governor was all right and the trouble was in the stop. The department head responsible for the condition of the equipment for tripping the automatic stop valve insisted it was all right. The general superintendent became interested in the matter and ruled that the automatic tripping device should be made inoperative. The result was, within 24 hours there was a bursted fly-wheel. In another case, an engine that drove a large continuous mill raced a number of times, tripping the automatic stop each time, sometimes when there was a piece in the passes. The delays were serious and annoying, so it was decided by someone connected with the rolling to block the engine stop. The result was, an 85-ton fly-wheel burst within a short time after killing the stop.

Another instance illustrates the importance of requiring stops to reveal impairment to installation by coming into action. An engineer in charge volunteered to demonstrate the reliability of his equipment, which was an open circuit installation with current furnished by a dry battery. When a station switch was closed the stop failed to respond, and investigation revealed that the battery was dead.

The turbines in a prominent power plant are equipped with motor operated valves that will shut off steam when dangerous overspeed occurs. On one occasion the control valve on one of the turbines failed and the motor operated valve automatically shut off the steam, but owing to the failure to provide against motoring by proper wiring, the turbine gained sufficient speed to do considerable damage before it could be stopped.

In the same power house they were trying out an installation of a 15,000 kw. turbo driven generator before completing the wiring to the motor operated valve. After starting the turbine the control valve failed, and it was only by quick action and taking much risk that the damage was limited to breaking of some foundation bolts.

Two accidents are called to mind where changes were being made in two turbine installations, each of which was supplied with an automatic stop, and in both cases they were trying out the installations with the automatic stops blocked or made inoperative. Four persons lost their lives in one of these accidents and two in the other by bursting of the turbines. One of these six who were killed, will always be remembered by the older members of the A. of I. & S. E. E. as one of its most respected and efficient members.

If we were to continue relating experiences we are familiar with we would prove most conclusively that where a flywheel burst, and in many cases where a turbine burst, the engine or turbine being equipped with an automatic stop, there was something lacking in the installation or there was some fault in caring for it that was responsible.

In codifying the general safety principles to govern the make and installation of automatic engine stops, consideration should be given to the wide variation in style, construction and purpose of machines they are to be applied to. It seems as though any of the principal makers of engine stops can furnish a design suitable for any requirement if it is rightly installed and maintained, and too, it seems as though it would be hard for anyone who has had an all round experience with all makes of stops, produced by different manufacturers, to decide on a preference to the exclusion of all others.

Experience has proven that the following hints are worthy of consideration:

Preference should be given to the closed circuit system. The most serious objection raised against it is, it possibly is more liable to be unintentionally brought into operation and cause inconvenience that the open circuit system is. So far as current failure is concerned this can be guarded against; so far as failure of wiring is concerned it seems best to have it revealed by action of the stop, regardless of the inconvenience that may be caused.

An open circuit system may be defective or out of order for a considerable period of time before its condition is discovered. Inspection and testing may be much neglected; the battery may have become exhausted or the circuit may be broken. However, these objections to both systems can be minimized

to a very large extent by proper installation of equipment.

Makers of valves have taken into consideration the importance of being able to reset a valve before an engine stops if necessary. Automatic valves should be so constructed that, through design or carelessness, they cannot be made inoperative and left in that condition while the engine is running, or in other words, so that the engine cannot be started or run unless the automatic stop valve equipment is in condition to perform its office.

Engine stops should be tested frequently to prove they are in good order. Such tests usually are made by using them when it is necessary to stop the engine, or they are made without stopping it and the reset is made while the engine is running. In addition to such tests, occasionally tests should be made by actually overspeeding. By whatever means overspeed is obtained, provision of some kind should be made for positively preventing the adjustment of the control governor, through ignorance or carelessness of an attendant, so that it will permit overspeed in excess of that which should be required for bringing the automatic stop into action, which speed should not exceed the normal required speed by more than 10 per cent.

Improper kind of packing around valve stems; improper balance of balanced valves; improper method of lubrication of parts of valves, are matters that can cause failure. These along with other defects in installation and make could be avoided if proper specifications were strictly followed in all cases, or if daily or even weekly attention were given.

Applying automatic stops to steam turbines seems to be important. Quoting a prominent author of a book on steam turbines, "The mechanical valve-gear does not often get out of order, but sometimes the unexpected happens. The shop man may not have properly set up the nuts on the valve stems; may have fitted the distance bushings between the shield plates too closely; the superheat of the steam may distort the steam chest slightly and produce friction that will interfere with the regulation. If any of the valve-stems should become loose in the crosshead they may screw themselves either in or out. If screwed out too far the valve-stem becomes too long and the pawl in descending will, after the valve is seated, continue downward until it has broken something."

All persons who are responsible for making installations of engine stops, and all persons charged with the responsibility of operating them, should be acquainted with the following list of causes for explosions, possible combinations, and improper methods:

Fly-wheel accidents are caused by overload or overspeed. Overload suddenly released will cause a flywheel to race. Overload may be produced by:

1. Clogging of the machinery in the mill or factory.
2. Unusual imposition of separate loads at the same time.
3. Careless or ignorant handling of friction clutches.
4. If the engine drives electrical machinery an overload may be produced by a short circuit, the sudden releasing of which causes the damage.
5. Sudden stopping of the engine due to obstruction or defects.

Overspeed causes the fly-wheel to explode by centrifugal force. By "overspeed" is meant the accidental increase in speed over that at which the fly-wheel will safely revolve, commonly called racing. Racing may be produced by:

1. Governor being improperly designed.
2. Slipping or breaking of governor belt.
3. Breaking of governor pulley.
4. Derangement of governor by internal or external causes, as when steam sticks or a rod breaks.
5. Derangement in valve gear.
6. Sudden reduction of load as when the main drive belt or clutch breaks or an armature burns out, etc.

Besides these principal causes there are contributing causes such as:

1. Failure of some part of an engine, as when its bed breaks or its shaft fails.
2. An idle pulley or driving pulley may break and hurl its fragments into the governor or valve gear.
3. Defects in design or material of the fly-wheel.

When a condensing engine overspeeds, even after the steam has been shut off, unless the vacuum is broken, racing may continue until the fly-wheel explodes.

When an engine starts to race, machines that it drives are shut down by the operators. The decrease in load causes a further increase in speed, which causes the fly-wheel to burst by centrifugal force.

For automatic engine stops the following combinations are possible:

1. Independent governors may be either:
   a. Electrically actuated,
   b. Steam actuated; or
   c. Mechanically actuated.
2. Combined trip and throttle valve.
   a. With magnet for closed circuit electrical operation.
   b. With solenoid for open circuit electrical operation.
   c. For closed circuit storage battery.
   d. For open circuit dry battery.
   e. To be steam actuated.
   f. Steam actuated and also fitted for open circuit electric operation.
   g. Steam actuated and also fitted with storage battery for open circuit electric operation.
   h. For mechanical operation.
3. Butterfly valve.
   a. With magnet for closed circuit electrical operation.
   b. With solenoid for open circuit electrical operation.
   c. With magnet for closed circuit storage battery.
   d. With magnet for open circuit dry battery.

The following methods and combinations for stopping an engine, should not be classified with automatic stops for quick closing.

1. A throttle valve attached through gearing to a motor or any mechanical appliance, for closing the throttle.
2. A mechanical device that is auxiliary to and connected to the control governor.

The following rules are suggested for guidance in operation of engine stops:

1. All parts of an automatic engine stop equipment must be closely watched by attendants, and kept in perfect condition all the time.

2. Engines that are supplied with automatic stops must be shut down by using the stops at least once each day, which means once each turn, if the engine is operated intermittently.

3. Engines that are run continuously for a long period of time must always be shut down when a stop is made, by bringing the quick closing valve into operation.

4. In addition to using the automatic stop when shutting down an engine, the apparatus must be tested once each day or turn to see if it is in perfect working condition.

5. Periodically, as conditions or convenience will permit, each engine stop must be tested by overspeeding the engine.

6. When an automatic stop operates unexpectedly and apparently the apparatus is in perfect condition, trouble should first be looked for in the control governor, and a test should be made by overspeeding the engine.

7. When a control governor is found to be out of order, immediate steps must be taken to put it in good order.

8. Where a trip is brought into action by a pin, projected by centrifugal force, the pin should be inspected, cleaned and oiled periodically as conditions will permit.

9. All parts of the valve and tripping devices, subject to wear and interference by foreign matter sticking to parts, must be kept constantly clean and lubricated. Cylinder lubricant must be admitted ahead of the automatic closing valve.

10. In the case of lubricating valves on steam turbines, if there may be any objection to admitting lubricant on buckets it must be admitted directly on the valve parts, in quantity just sufficient to effect perfect and continuous lubrication.

Anti-Friction vs. Sleeve Bearings

By J. S. MURRAY*

THE present attention on the part of many of the members of this association seems to be directed to the relative merits of ball and roller bearings versus the sleeve type of bearings now in use on steel mill motors.

Those who have operating experience know only too well that a majority of all winding failures can be attributed to oil and grease being deposited on the winding. This oil and grease comes from the bearings by leaking out on the shaft and gradually creeping into the windings.

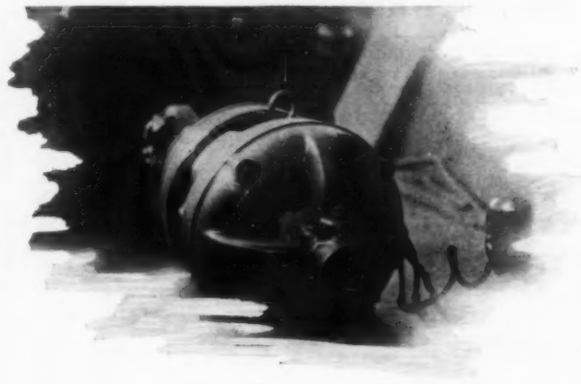

FIG. 1.

The fundamental cure for this trouble would appear to be to provide a sleeve bearing that would retain the oil or grease in the bearing, thus not only preventing damage to the windings but also insuring long life of bearings and necessitating but little attention, or by providing a bearing of the roller or ball type where the probability of excess lubrication and leaking of same into the motor is slight.

*Chief Electrician, Follansbee Brothers Company, Toronto, Ohio.

While the roller bearing may offer relief for bearing trouble which has been experienced with the older lines of motors, particularly where the service is severe, the question of adopting a roller or ball bearing as standard motor practice in the steel industry, presents a number of problems such as changeover expense and future maintenance, particularly from the standpoint of renewal parts. These problems should be carefully and definitely analyzed before a decision is made to adopt a radical change of this nature.

FIG. 2.

During the last few years, a great deal of field data has been submitted by the various members of the association relating to their experiences with ball and roller bearings, and pointing out the unsatisfactory features of the sleeve bearings. This has been a material factor in stimulating a general interest in the improvement of the bearing art by the motor manufacturers. As most of the discussion on this subject has centered on the question of oil leakage, it seems advisable to review the progress which has been made to overcome this undesirable feature of the sleeve bearing.

My attention was recently called to some important modifications of sleeve bearing design incorporated in the latest type of induction motors as built by one manufacturer and it might be of interest to give the results obtained by several months of experience with these new bearings.

We previously had considerable trouble with the throwing of oil on motors running 1200 and 1800 rpm. and were much interested in determining what could be done to eliminate this trouble by means of this improved type of sleeve bearing.

We accordingly installed some of the motors referred to, having this improved bearing housing construction. Fig. 1 shows a 25 h.p., 3-phase, 60-cycle squirrel cage induction motor, 1800 rpm., 230-volt, operating in a very dirty location on a booster fan which we fitted with a set of Sealed-Sleeve bearings on September 3, 1923. This motor has not been oiled since that date and to show that there is no oil leakage, the shaft outside the bearing is actually rusty, while the windings are bone dry. We understand this result has been secured by close attention to design details and from the service that we have obtained we are strongly of the opinion that a successful leak-proof sleeve bearing of a practical design has been produced for this motor and will soon be available not only for this type of motor but for other types of motors used in the steel mills. This will eliminate the confusion and expense that would undoubtedly be incurred by a change to a radically different type of bearing, especially for the existing lines of motors as now installed.

We have recently made similar changes on other motors with equally satisfactory results. We expect to continue to make further changes along this line in the future and we will be glad to give any who may wish to inquire, or visit our plant, further information regarding our experience with this new Sealed-Sleeve bearing.

Fig. 2 shows another installation of the same type of bearing with similar results obtained as with the original installation shown by Fig. 1.

In conclusion, I wish to suggest that this association proceed slowly and cautiously on this bearing question and by close co-operation, lend their encouragement to the motor manufacturers in their endeavors to improve the sleeve type of bearing. It does not seem that now is the time to make a decision regarding a radical change in motor bearing design such as would be occasioned by a change to the roller or ball bearing type.

G. R. McDERMOTT, Chairman W. P. CHANDLER, Secretary

FUEL SAVING'S CONFERENCE

April 2nd-3rd, 1924 - - Wm. Penn Hotel

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Auspices Combustion Engineering Section of

Association of Iron and Steel Electrical Engineers

PROGRAM

Wednesday, April 2, 1924—

BOILERS

"Prevention of Scale Formation by Boiler Water Conditioning," by Dr. R. E. Hall, Physical Chemist, United States Bureau of Mines, Washington, D. C.; Carl Fisher, Superintendent of Heat, Power and Light, Mesta Machine Company, Homestead, Pa., and George W. Smith, Chemical Engineer, Hagan Corporation, Pittsburgh, Pa.

"Measurement of Input and Output of Boiler Rooms," by J. M. Spitzglass, Engineer, Republic Flow Meter Company, Chicago, Ill.

"Ljungstrom Air Preheater," by B. G. Brolinson, Engineer for Aktiebolaget Ljungstroms Angturbin, Wellsville, N. Y.

Topical Discussion—"Coal Losses Due to Standby Steam Requirements and Demands."

Thursday, April 3, 1924—

HEATING FURNACES

"Heating Furnaces," by A. L. Culbertson, Manager, Chapman Stein Furnace Company, Mt. Vernon, Ohio.

"Producers," by W. P. Chandler, Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

"Oxygen Enrichment," by F. W. Davis, Bureau of Mines, Washington, D. C.

INSPECTION TRIPS

Visit to the Allegheny County Steam Heating Company. (Largest boiler in the world, about 3,000 hp.)

Visit to the Jones & Laughlin Steel Company, Eliza Furnaces. (Blast furnace gas fired boiler plant and modern 10,000-kw. power station.)

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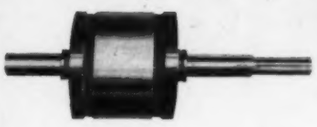
W. P. Chandler	W. N. Flanagan	C. H. Hunt	W. J. Harper
A. G. Witting	F. E. Leahy	J. W. Miller	J. C. Allen
H. C. Seibert	L. C. Edgar	M. J. Conway	

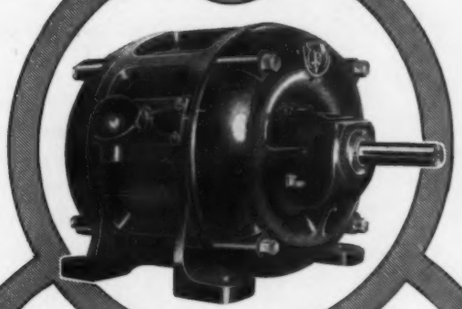
WHY IS THE NC MOTOR BETTER



Rotor

Bearing

Stator



End Shield

1st. It is a 40° Motor with the two hour overload rating.

2nd. It has higher power-factor, efficiency and torque.

3rd. The Bearings are larger and each Bearing has two Oil Rings.

4th. All sizes are made with open slot construction.

5th. All Coils are treated twice with a vacuum impregnating process and in addition given numerous dipping and baking treatments.

6th. The Coils are waterproof and oilproof.

7th. Larger Oil Wells are supplied, thus insuring a generous supply of clean oil and very little attention.

8th. Most of the cooling is done by natural radiation and not by forced ventilation.

9th. End Rings are cast onto the rotor bars.

10th. All parts are so carefully and accurately machined that no fitting is required.

There is not enough space on this page to describe the minor points of superiority, but they can be had for the asking.

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That night the good fairy came to Jones

HIS friends tell a story on General Manager Jones. They say one night he dreamed a Good Fairy came to him right out of the book and told him to make a wish. And Jones sat up in bed and shouted:

"I wish I knew a way to get more PRODUCTION!"

Very well, Mr. Jones. Listen to this:

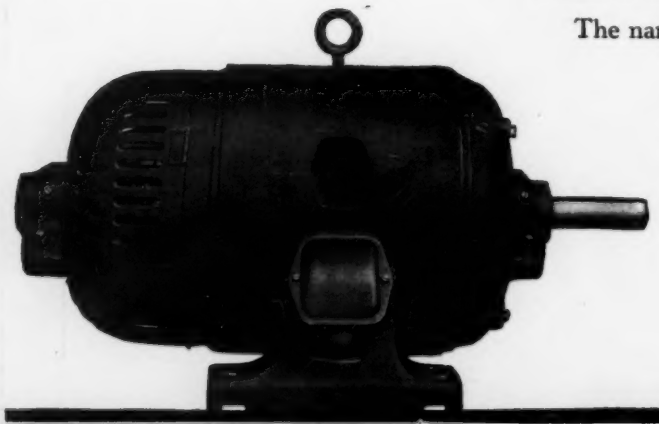
Did you ever think of the effect on production of the speed characteristics of your motors?

You have scores of induction motors driving your machines. The Central Station man isn't any too pleased when you put more of them on the line, and when you complain of poor voltage, he tells you it is due to your bad power-factor. That seems more annoying than serious, perhaps. It hasn't occurred to you that the motors, besides being a trial to the Central Station, are *holding back your production*.

They lag a little in speed all the time; more than a little, a good deal of the time. As the voltage drops you are lucky if they don't stop entirely. The combined effect of the lagging on all the machines in the shop will put quite a hole in the production figures.

Now suppose a motor that operates at synchronism—at a perfectly uniform speed higher than that of an induction motor for the same power input—over practically your entire load range; that starts as easily as an induction motor, and requires no more care; and at the same time, by correcting your power-factor, helps keep voltage uniform. Think of the gain, not only in general efficiency, but in PRODUCTION.

The name of that motor is THE FYNN-WEICHSEL MOTOR.



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Fynn-Weichsel

The motor that corrects power-factor

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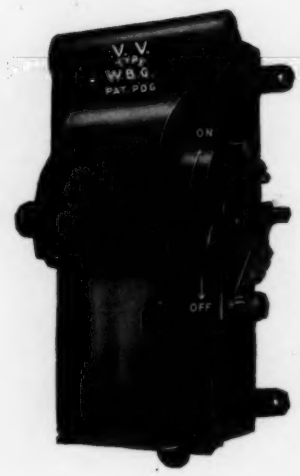

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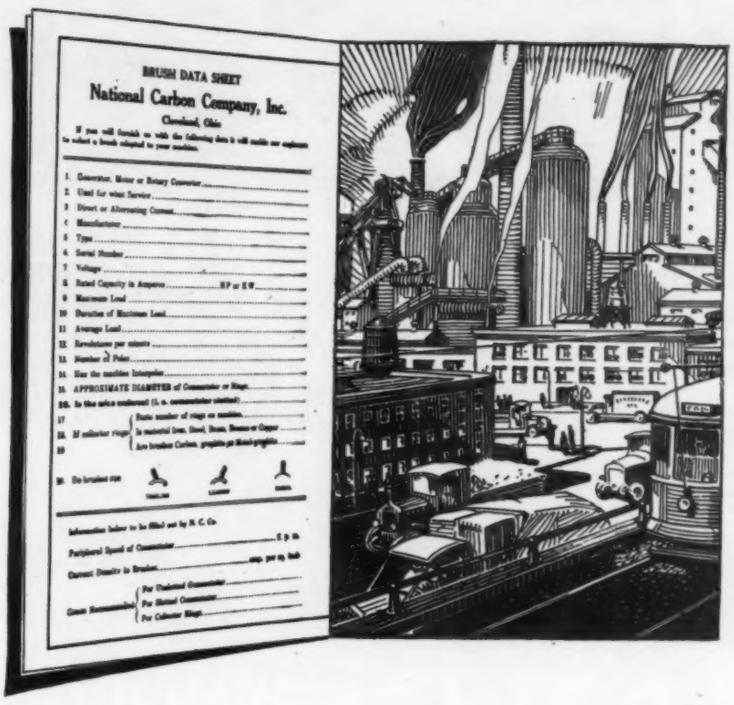

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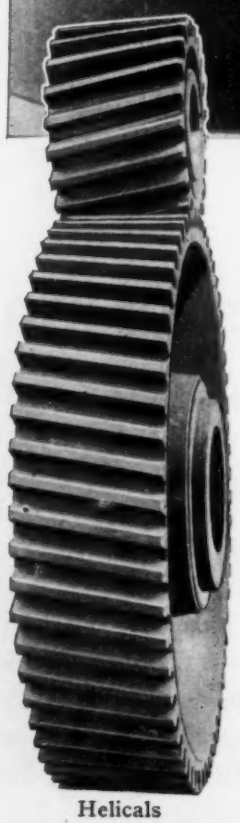

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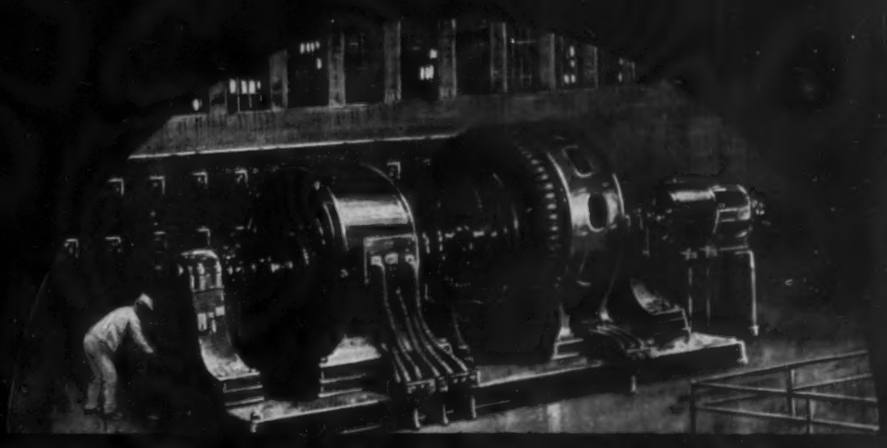

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INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs when they install Economy renewable Fuses in the place of "one-time" fuse-equipment.

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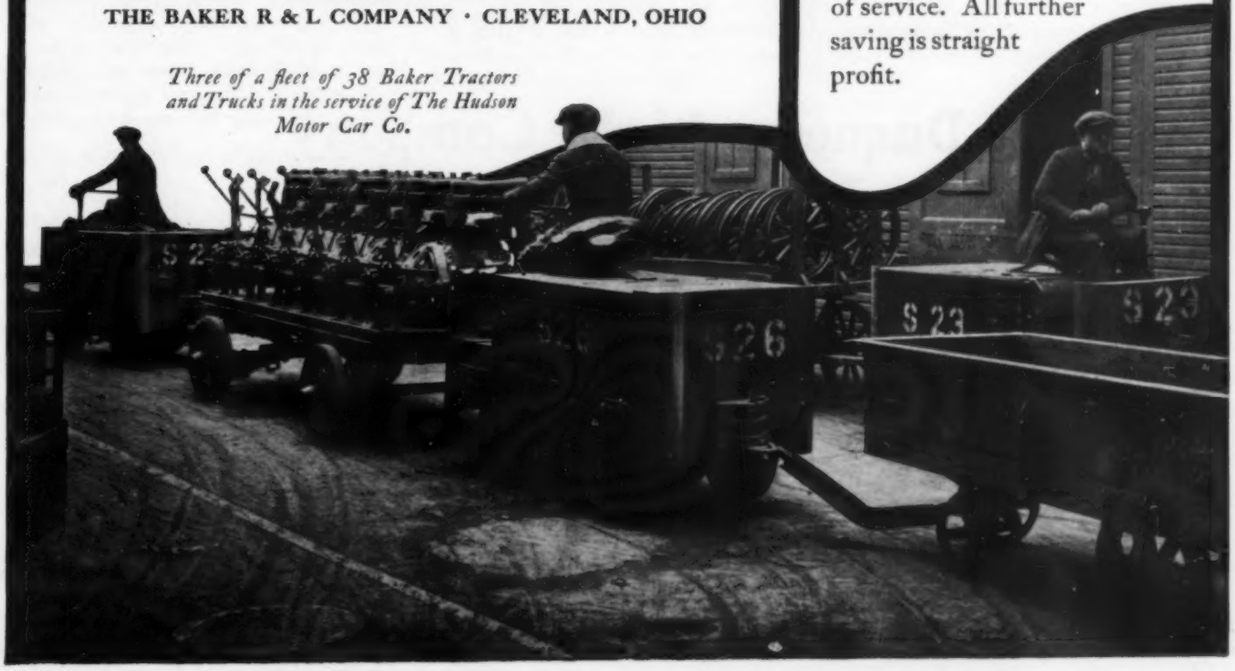
Three of a fleet of 38 Baker Tractors and Trucks in the service of The Hudson Motor Car Co.



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This plant is featured by the largest boiler in the world, its rated boiler horsepower capacity being in excess of 3,000. Aside from its size, it is of exceptional interest to the engineer because of the many advanced steps which have been made in its design.

An invitation is extended to the A. I. & S. E. E. to visit and inspect this plant during the Fuel Saving Conference in Pittsburgh April 2 and 3.

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Live in and expand your business in Greater Pittsburgh.

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Poor Lubrication
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THE Keystone Manifold Safety Lubricator combats them all in new, efficient ways.

Send him back to them—*Safe*

"CLOSE shaves! Man! You do think of the home folks at times." Risks are demanded daily to lubricate properly certain bearings. Close clearances, hard-to-reach bearings take a toll—but let the figures tell the story.

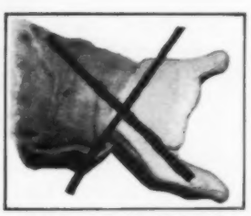
Think! 163 accidents in one industry alone last year were due to men being caught in machines while lubricating them, 2558 days of productive time was lost. Another industry reports 442 such accidents.

Loss of life! Loss of limb! Loss of profits!

This is no small matter to pass off lightly. Taking the hazards out of lubrication is vital to you, as it is to every other big industrial executive.

Obviously this costly toll will continue just as long as an operator visits each and every bearing individually, but this is no longer necessary, nor are the attending risks.

Thru the installation of the Keystone Manifold Safety Lubricator the operator stands in one safe place and, turning a wheel, lubricates the whole machine — positively — economically—*safely*.



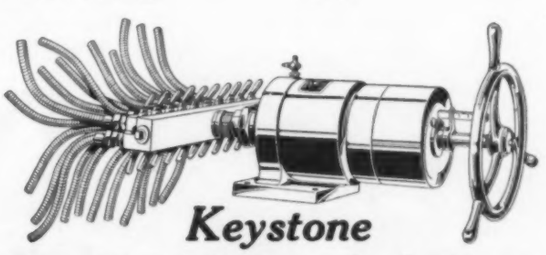
End this menace to life and limb

The Keystone Manifold Safety Lubricator presents a method of applying Keystone Grease under high pressure, with pipe line distribution, to more than one bearing.

No waste of grease; no risk to operator; no dirt in bearings; no shut-down for lubrication; no excuse for neglect.

Oust risk and you minimize neglect —friction's costly toll of power loss —wear—and premature scrapping of machinery.

Figure out just what this would mean to your operating schedule, your employees, your profits. Then write.



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Different plants, operating under different conditions with different types of machinery, require different methods and forms of lubrication. All the knowledge of scientific plant-operation gathered by our lubrication engineers is at your disposal—a survey of the conditions in your plant and our recommendations will cost you nothing. Branches in every important city. Agencies throughout the world.

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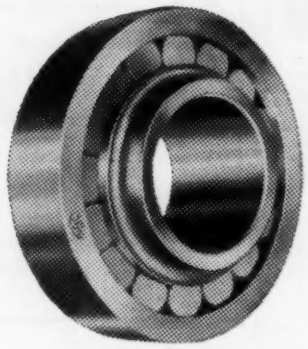
SPECIALIZED SERVICE

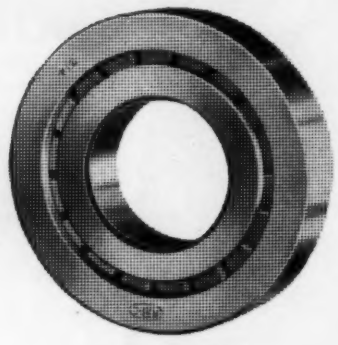
A Type for Every Condition



TYPE MDW

For replacing all types of Babbitt and Brass Bearings in Mill Table, Screw Down, Crane, Foundry, Open Hearth, Ore Bridge, Centering Plant, Cement Plant, Motors.

Suitable for Mining Machinery, Forging Machines, Turn Table, Electric Cranes and Charging Machines, Hot Saws, Cold Saws, Large Shafting, Calendar Rolls, Crushing Machinery.

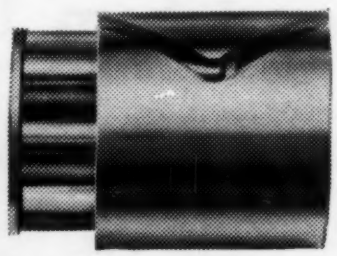


TYPE M

Interchangeable with standard Ball Bearings. Used in Mill and Mine Motors, Storage Battery Trucks and Tractors, and Grinding Machinery.

THRUST TYPE

Turbine Pumps, Turbine Generators, Screw Hoists, Jacks, Crushers, Crane Hooks, Vertical Motors, Mine Machinery, Clutches, Forging Machinery and Turn Tables.



W. S. TYPE

Open Hearth Ingot and Scrap Box Buggies, Coal, Coke, Ore and Ash Handling Machinery, Conveyors, Mill Table Rollers, Mill and Shop Line Shafting, Leveller Rollers, Hand Trucks, Foundry Cars, Hand Cranes, Furnace Covers, Plate Mill Casters, Blowing Machinery, Sheave Wheels, and Tractors.

ROLLWAY BEARINGS

Manufactured by

ROLLWAY BEARING COMPANY, Inc.

SYRACUSE, NEW YORK

THE AERIAL RAILWAY
of INDUSTRY
SHEPARD
ELECTRIC CRANE AND HOIST CO.
MAIN OFFICE AND WORKS - MONTOUR FALLS, N. Y.
Throughout the Plant and Yards

"To all points without change"

An outline of— "Express train" service for handling the heavier loads

IT describes a "rapid transit" method of moving materials and tells how a load can be picked up in one department and carried, ***through without change,*** to another department—how, by means of overhead transportation, material is moved from cars, receiving platforms, to any one of many points within a building or yard.

It is a story of the Shepard "Aerial Railway of Industry," which consists of one or more Shepard Cage Control Electric Hoists operating on Shepard Transfer Crane, and overhead I-Beam Track. Read it and learn how one man, the operator who rides in the cage of the hoist, can switch his load from main track to crane, to spur track, and vice versa.

The application of our "Aerial Railway" is wide, and this equipment has developed most unusual economies in hundreds of plants.

We'll promptly send this book upon receipt of your request.

SHEPARD ELECTRIC CRANE & HOIST CO.

382 Schuyler Ave., Montour Falls, N. Y.

Branches in Principal Cities

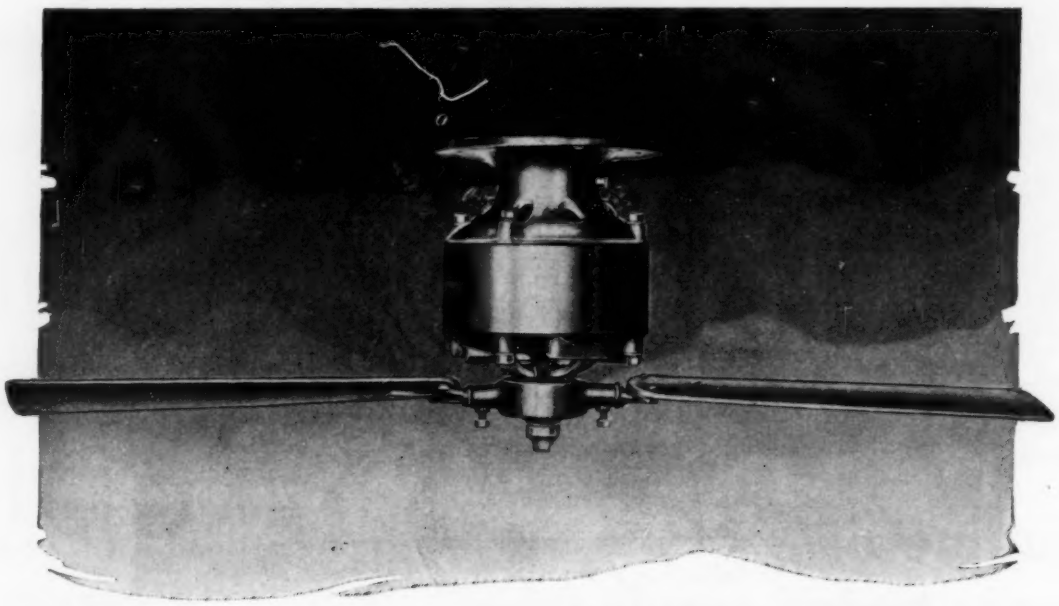
Member of Electric Hoist Mfrs. Assn.

REG. U.S. PAT. OFF.

SHEPARD

ELECTRIC CRANES & HOISTS

SKF



Ball Bearings on Vertical Motors
Simplify Construction—Reduce Maintenance

HESS-BRIGHT deep-groove ball bearings on ceiling-fan motors eliminate the need of separate thrust bearings, thereby simplifying construction and avoiding the difficulty of keeping plain thrust bearings properly lubricated.

Furthermore ball bearings are readily housed for the retention of the lubricant —a distinct advantage in that "grounds" due to oil leakage are avoided. An inspection and re-greasing of the bearings every three or four months is all the attention required for ball bearings, being non-wearing, require no adjustments or replacements.

These advantages of deep-groove ball bearings have led to the widespread adoption of this type of **SKF** marked ball bearing on vertical electrical machinery. Ball-bearing recommendations for vertical and horizontal electrical machinery of any capacity will be gladly made upon request. Let us know your problems.

THE HESS-BRIGHT MANUFACTURING COMPANY

Supervised by **SKF** INDUSTRIES, INC., 165 Broadway, New York City

1124

Cross Section of Single-Row Bearing

Cross Section of Double-Row Bearing

The Good Performance of C-H Magnetic Type Controllers—A Result of Contactor Design

Standing in the background but yet governing the operation of huge motors and the machines they drive, C-H Magnetic Control Panels play an important part in industrial output in every corner of the country.

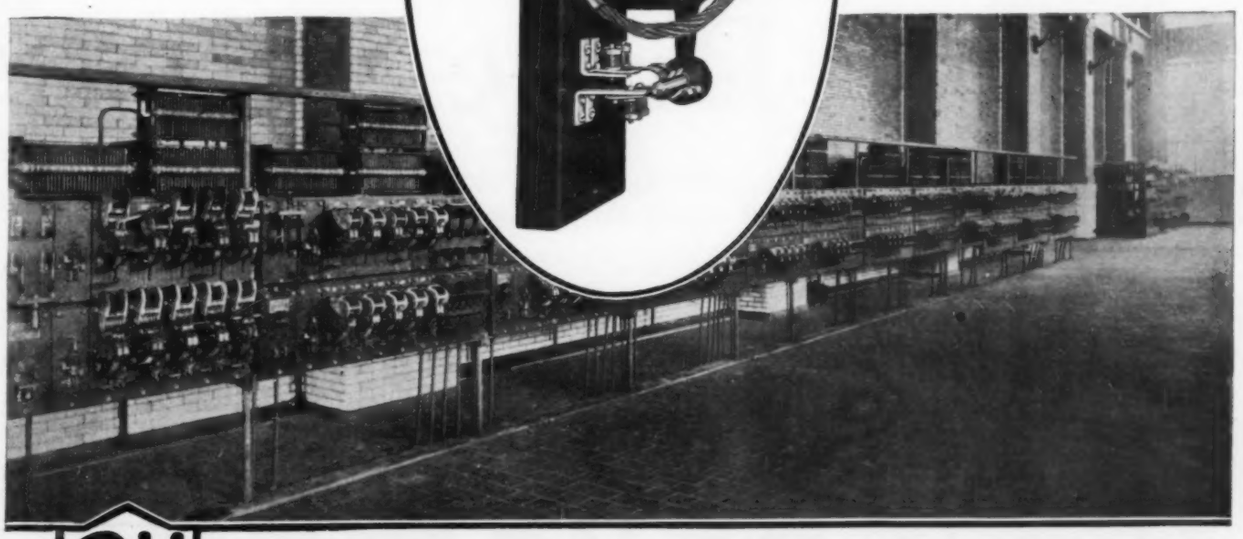
The unusual performance is a result of the skillful design and long life of the C-H Contactors that go to make up these control panels. Every design and construction feature has been given the most careful attention as exemplified, for instance, in the No. 142 (300 Amp.) D. C. Contactor.

This switch is small compared to some contactors, yet a giant in other ways. It requires less space, making possible smaller dimensions for the control panel. The specially designed C-H coils are readily removable without disturbing wiring; the butt contacts are easily replaced; a powerful copper bar blow-out is provided; and an arc shield lined with C-H fire-resisting Pyroplax coated with fireproof cement.

And in addition to these electrically and mechanically superior contactors there is available to motor users the long experience of Cutler-Hammer engineers in the application of controller equipment to motor drives.

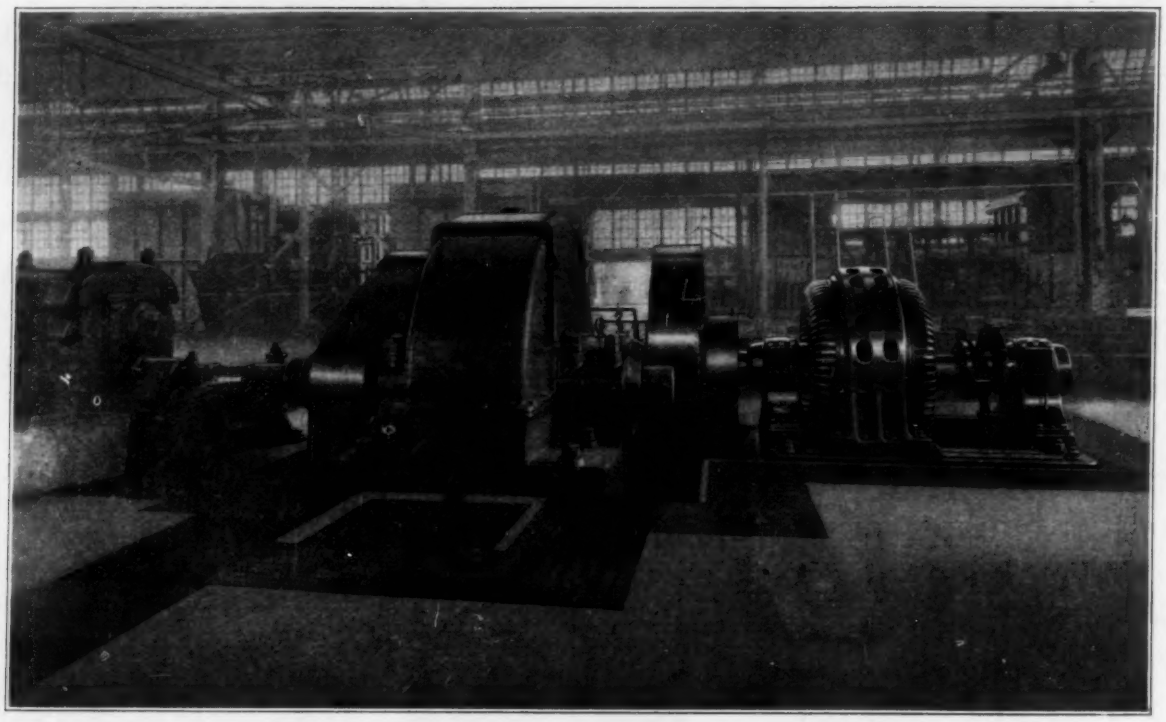
THE CUTLER-HAMMER MFG. CO.
Motor Control Department
Works: MILWAUKEE *and* NEW YORK
Offices and Agents in Principal Cities
Northern Electric Co., Ltd., Can.

C-H Automatic Control Equipment used with Blooming Mill Motor Drive.



C-H CUTLER-HAMMER **MAGNETIC CONTACTORS**

ALLIS-CHALMERS



Merchant Mill Drive

1000 H.P., 2200 volt, 60 cycle, 3 phase, 450 R.P.M., Steel Mill Type, Slip Ring Induction Motor, drives 20-in. Merchant Mill—International Nickel Company, Huntington, W. Va.

ALLIS-CHALMERS PRODUCTS
Electrical Machinery
Steam Turbines
Steam Engines
Gas and Oil Engines
Hydraulic Turbines
Crushing and Cement Machinery
Mining Machinery

ALLIS-CHALMERS MANUFACTURING COMPANY

MILWAUKEE, WISCONSIN, U.S.A.

ALLIS-CHALMERS PRODUCTS
Flour and Saw Mill Machinery
Power Transmission Machinery
Pumping Engines-Centrifugal Pumps
Steam and Electric Hoists
Air Compressors - Air Brakes
Agricultural Machinery
Condensers

A fuse as permanent as the panel board

The only purpose of a renewable fuse is to provide for renewal without repurchase of the whole fuse. If repurchase of the whole fuse is be avoided, the fuse case must actually *be* permanent.

Permanency, under normal conditions, depends upon:

1. **The quality and strength of materials used.**
2. **The design of the fuse itself.**

The quality of materials used in Buss fuses needs no discussion—the unusually heavy fibre case and the extra rugged metal parts are self evident.

But even with such strength of construction, permanency would not be assured except for Buss design.

Poor contact due to poor design is the chief cause of renewable fuse destruction. Buss design prevents the possibility of poor contact by avoiding designs which permit variation in the manufacture, assembly or use of the fuse.

The full length cap provides a one-piece, undivided, perfectly even surface for contact with the fuse block clips.

The firm grip of the clip keeps vibration from loosening the cap, which, therefore, maintains contact pressure on the link. The projection inside the cap gives positive bearing on the link. The recess around this projection collects expelled metal, when the fuse blows on a heavy short, thereby preventing sticking of the cap and injury to the contact surface.

By avoiding constructions that permit poor contact, Buss has added years of life to the fuse and saved thousands of dollars annually in preventing useless blowouts.

When you insert a Buss Fuse in the clips, you do it with a feeling of confidence. It is there to stay—a trusty watchman of your circuit. It blows to protect but never to cause useless shutdowns and expense.

If you are not thoroughly acquainted with the BUSS Ferrule Contact Renewable Fuse, clip the coupon on the next page.

BUSS FUSES

APPROVED IN ALL TYPES AND SIZES

TRADE BussFuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

"ELECTRICITY'S SAFETY VALVE" MEANS ONLY BUSS FUSES.

A fuse that lasts as long as the things it protects

There is nothing mysterious about the long life of the Buss Knife Blade Renewable Fuse. It results from certain common-sense features of construction that eliminate the primary causes of fuse destruction.

Buss design has first of all taken care of the human factor in fuse renewal waste. Just three parts and the link—that's all. No hinges, wings, screws or washers to handle. No tricky or annoying adjustments to make. No possibility of a Buss fuse being discarded by an inexperienced or irritated workman because of difficulty in renewing. No possibilty of premature blowouts due to link being bent or injured in renewing the fuse, because the terminal support holds the link rigid.

Injury to the case due to gaseous pressure developed by a heavy short is prevented by the knurled venting discs which insure positive, reliable and

controlled escape of gases. Sufficient pressure is retained within the case to quench the arc but enough is permitted to escape to avoid excessive pressure.

Poor contact, that greatest of all destroyers of fuses, is avoided through perfect alignment of terminals. One terminal is seated in a slotted opening just large enough to let it pass. The other terminal is accurately lined up in exact position by projections on the venting disc fitting into notches on the end ring.

The use of the Buss Renewable Fuse gives a freedom from annoyance and a satisfaction of absolute protection at the lowest possible cost, that cannot be had in any other way. It is truly the fuse whose life is as long as that of the things it protects.

If you would like to examine a BUSS Knife Blade Renewable Fuse, clip the coupon.

BUSSMANN MANUFACTURING CO.
3819 No. Twenty-Third St., St. Louis, Mo.
Without obligation send me for examination (check which you want)
☐ Sample 30 ampere, 250 volt Ferrule Contact Type Buss Renewable Fuse.
☐ Sample of 100 ampere, 250 volt Knife-Blade Type Buss Renewable Fuse.
IR 3-24

Name
Company
Position
Street
City
State

BUSS FUSES

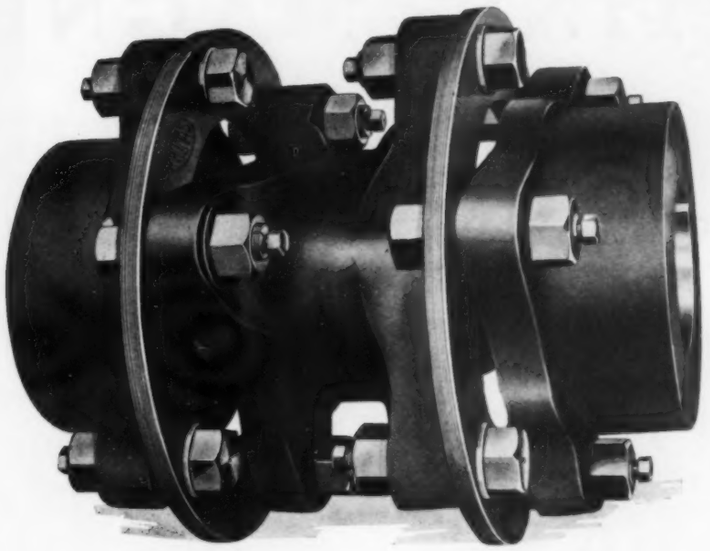
APPROVED IN ALL TYPES AND SIZES

TRADE BussFuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

CTRICITY'S SAFETY VALVE" MEANS ONLY BUSS FUSES.

THOMAS FLEXIBLE COUPLINGS

FOR HEAVY DUTY ROLLING MILL SERVICE



The successful application of the Thomas Mill Type Coupling now includes practically every type of mill, representing, today, over one hundred and fifty (150) installations. They successfully overcome all the drawbacks of the present day mill spindles and flexible couplings. They offer no frictional resistance to motor rotor float under any conditions of load or misalignment. The elimination of loosely connected members removes all wear, back lash and the hammering action which always exists and which has proven so destructive to motors, spindles, shafts, gears and other parts of the mill.

Thus they decrease maintenance charges and insure continuity of operation.

Put Your Problems Up To Us.

THOMAS FLEXIBLE COUPLING CO.

MAIN OFFICE AND WORKS—WARREN, PA.

Sales Offices: New York, Chicago, Cleveland, Philadelphia, Pittsburgh, Boston, St. Louis

C. H. Hills, Special Representative, Springfield, Mass.

OHIO
LIFTING MAGNETS

Reprinted from

16 INDUSTRIAL HANDLING *October, 1923*

Magnets Save Steel-Plant Labor

The lifting magnet that enabled the Otis Steel Company of Cleveland to release 70 loaded cars, empty in 24 hours.

WHEN Judge Gary committed the United States Steel Corporation to an eight-hour day for labor, he made the statement that the improvement would require 60,000 additional laborers for the industry. Because the steel business always has been able to get cheap labor, it has been criticized for neglecting to develop the labor-saving side of its operations to the fullest extent. Doubtless it would also have been criticized if it had so dispensed with some of its labor.

There is one type of material-handling equipment, however, which is not only put to intensive use in the steel industry, but is peculiarly adapted to the characteristics of that business; and that is the lifting magnet. This device has the interesting ability to make the load perform part of the work, by reason of the magnetic nature of steel and iron.

During the war the Otis Steel Company of Cleveland, O., had more than 70 cars in the yard loaded with pig iron and scrap, and was ordered to release these cars empty, within 24 hours. The company had one magnet in operation for loading, and, when the order came, rented a second magnet—the one shown in the picture. With this equipment the government order, seemingly a difficult one, was easily met.

The lifting magnet will usually repay its full cost in a year or less.

The Ohio Electric & Controller Co.
Cleveland, Ohio

OR ASK OUR REPRESENTATIVE

A. J. Haywood, 88 Broad St., Boston, Mass.
Hunter L. Betts, 405 So. Franklin St., Syracuse, N. Y.
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S. G. Elbe, 211 Tramway Bldg., Denver, Colo.
G. H. Armstrong, 307 First National Bank Bldg., Cincinnati, O.
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Carl Johnson, 331 Houseman Bldg., Grand Rapids, Mich.
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Linn O. Morrow, 707 Franklin Trust Bldg., Philadelphia, Pa.
Nixon-Hassele Co, Chattanooga, Tenn.
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C. E. Wise, General Motors Bldg., Detroit, Mich.
D. O. Stewart, 617 Bank of Commerce Bldg., St. Louis, Mo.

BENJAMIN

Makers of Things More Useful

An Installation of Benjamin Elliptical Angle Reflectors

Benjamin Elliptical Angle Reflector Socket

For use where overhead conditions make lighting from the side desirable.

For wide bays to supplement overhead lighting with intense lighting from the side.

They light up not only wide areas in a horizontal plane, but throw a flood of light on vertical surfaces as well.

Especially useful, indoors or out, where service conditions require a heavy duty unit.

The Crysteel Porcelain Enamel is easily cleaned and makes the reflector highly resistant to moisture, smoke, gases and the dust and dirt of heavy industrial processes.

Equipped with heavy type X weatherproof fitting and two-piece porcelain, easy-to-wire keyless socket. Benjamin lamp grip prevents loosening and falling of lamp under vibration.

Where there is the possibility of unauthorized removal or theft of lamps, they may be fitted with Self-Locking Socket.

Our nearest office will gladly give further information
Send for new Bulletin on Industrial Lighting

BENJAMIN ELECTRIC MFG. CO.
847 W. Jackson Blvd., Chicago
247 W. 17th Street, New York — 580 Howard Street, San Francisco
Pittsburgh District: P. O. Box 807; Phone Court 2032

"For every requirement in Industrial Illumination"

Electrical Engineering and Manufacturing Company

General Office

PITTSBURGH, PA.

We are prepared to furnish your requirements in the following materials and equipment:

"MORGANITE" Carbon-Graphite Metal Brushes.

"ROWAN" Automatic Controllers and Starters.

"SUMET" Bronze and Babbitt Bearing Metals.

"DUTCHESS", Empire or Varnished Cloth and Tape.

ELECTRICAL INSULATING Varnishes and Compounds.

"BELL" Cedar Poles.

CROSSARMS; Douglas Fir and Pine.

LINE MATERIALS; Hangers, Brackets, etc.

TRACK GRINDERS; Reciprocating and Rotating.

"AJAX" Welding and Bonding Machines.

MINE HOISTS and Winches, Car Pullers, etc.

HIGH and **LOW** Tension Insulators.

"ELPECO" High and Low Tension Switching Equipment, Bus Fittings, etc.

We have a corps of expert engineers, specialists in the above lines, who will be glad to give immediate attention to your inquiries or to see you at your request for consultation regarding applications or equipment. Call or write our nearest office.

CINCINNATI, OHIO
607 Mercantile Lib. Bldg.
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Phone Prospect 1252

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907-909 Penn Ave.
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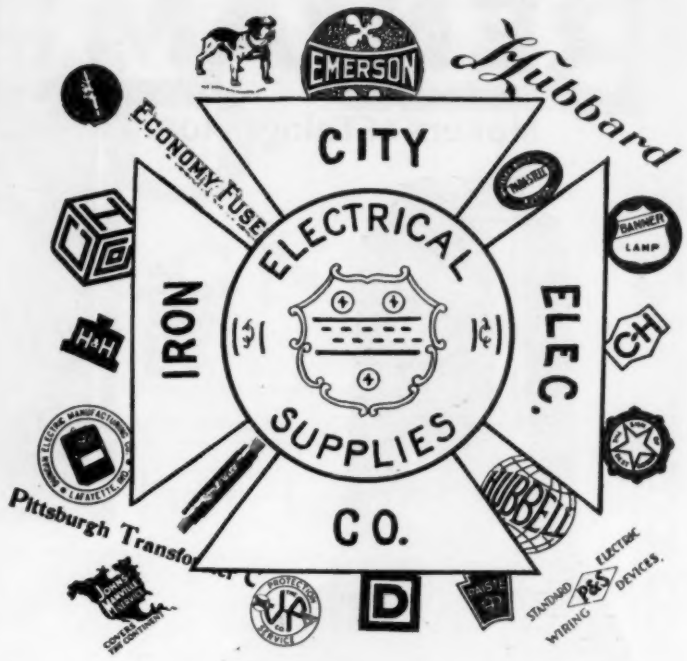


The Trade Mark

of the

Iron City Electric Co.

436-38 Seventh Avenue

Pittsburgh, Pa.

REPRESENTING

"The House That Service Built"

IS BACKED BY A GROUP OF

TRADE MARKS

of Well Known Manufacturers Guaranteeing the Quality of the Goods You Receive

"Notice the lighting" in this auto assembly plant —Appleton Swivel Joints keep the fixtures lined up.

Unilet Swivel Joints allow fixtures to swing through an angle of approximately 15 degrees from the perpendicular.

Insures Perfect Alignment of Lighting Fixtures

Appleton Swivel Fixture Joints and Covers are designed to provide and maintain the perfect alignment of pendant lighting fixtures that adds so much to the general appearance of large factory rooms where the lights are hung in long rows. Lighting engineers also recommend the use of Appleton Swivel Joints and Covers because fixtures must be hung plumb if they are to do their part in producing a uniform distribution of light throughout the plant.

Eliminates Breakage

The Appleton Swivel Joint allows the fixtures to swing in any direction through an angle of at least 15 degrees from the perpendicular. This flexibility prevents damage or breakage when the fixtures are struck by ladders, pipes, boards or moving machinery as they frequently are in every busy plant.

You will find these efficient little fittings fully pictured, described, and priced on pages 156 and 183 of Catalog 9-T, which lists all Appleton products—"Unilets" (one for every wiring need), "Uniduct", Conduit Clamps and Hangers, Switch Boxes, and the famous "Reelites".

Catalog 9-T has a pictorial index which is a great help in locating special fittings — If you know what you want, you can easily find it in the pictorial index even though you do not know what to call it.

You may not need Catalog 9-T right now but you undoubtedly will in the near future so write for a copy today and have it on hand when the emergency arises.

Outlet Box Cover equipped with Swivel Fixture Joint—Made in all standard shapes and sizes.

Unilet Swivel Fixture Joint —When used in conjunction with a Unilet this joint supports the fixture and the Unilet provides a separate wiring chamber for the connections.

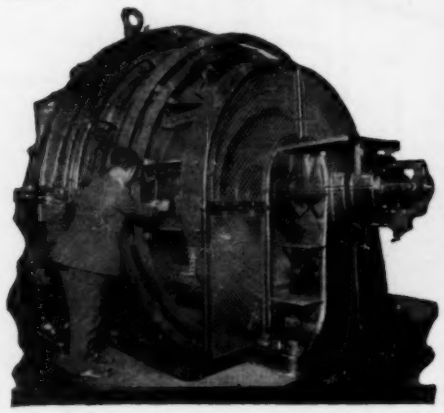
Combination Hickey and Swivel Fixture Joint — The hickey feature greatly facilitates wiring.

APPLETON ELECTRIC COMPANY
1717 Wellington Avenue
CHICAGO

APPLETON

why don't you?

give us the privilege of demonstrating the Ideal method of Commutator conservation.



Lengthen the life of your generators or motors by years, in a simple, inexpensive manner.

The greatest efficiency can be obtained from an electrical machine only when commutation is as near perfect as possible. Sparking can be eliminated, high mica, rough spots and grooves smoothed down and the wear trued up, avoiding defective operation and expensive repairs, through the regular use of the Ideal Resurfacers. A size and grade for every type of machine. If you are unacquainted with the Ideal, and doubt its wonderful possibilities as a money saver, take advantage of our free trial offer.

Ideal Commutator Dresser Co.
5315 North Western Ave., Chicago, Ill.

free trial offer

Ideal Commutator Dresser Co.,
5315 N. Western Ave., Chicago.

Gentlemen: Please send me an Ideal Commutator Resurfacer for free trial. If I like it I'll pay for it. If I don't like it I will return it The trial will have cost me nothing. I want to use it on equipment as follows:

Approx. R.P.M.....
Diameter of Commutator or Ring.....
Approx. Width of Commutator or Ring Surface.....
Approx. Distance Between Brush Sets.....Condition.....
Collector Ring or Commutator Material.....
Name..... Position.....
Company..... Company Address.....
City ..... State.....

A.I.S.E.E. 3-24

1891 — 1924

MORGAN
Construction Company

Worcester, Mass., U.S.A.

Designers and Builders of

Morgan Continuous Mills

for

Billets, Sheet Bars, Skelp, Merchant-Bars, Hot-Strip, Rods

also

Wire Drawing Machines
Producer Gas Machines
Straightening Machines
Isley Reversing Valves
Re-Heating Furnaces
Reducing Gear Units
Shears

Our Engineering Department

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product

1891 — 1924

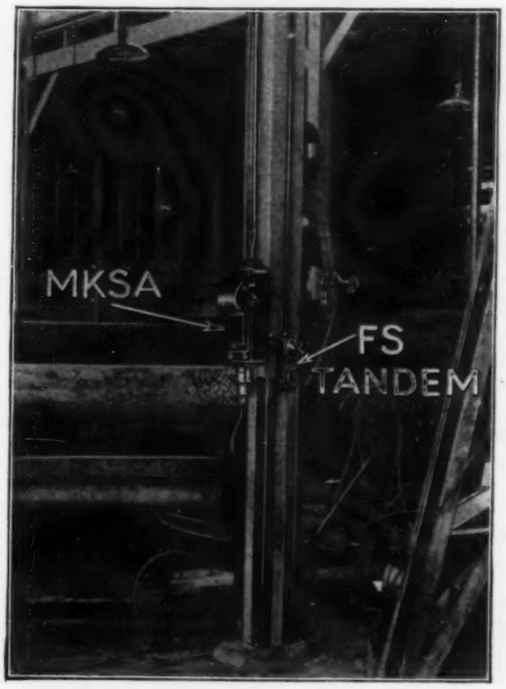
CONDULETS

TYPE MKS

Interlocking Safety Switch and Plug

Simple in Construction, Positive in Action, and 100% Foolproof

TYPE MKS
WITH INTERLOCKING PLUG
FULLY INSERTED



FOUNDRY: AN INTERLOCKING SAFETY SWITCH AND PLUG INSTALLATION

CH 123

Impossible to throw the switch "on" before the plug is fully inserted and the door of the fuse compartment closed.

Impossible to withdraw the plug or open the door of the fuse compartment before the switch is thrown "off."

Write for Bulletin No. 2053

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

SALES OFFICES
NEW YORK BOSTON CHICAGO
PHILADELPHIA DETROIT ST. LOUIS MINNEAPOLIS
CINCINNATI SAN FRANCISCO

CROUSE-HINDS

It Outlasts All Others

BECAUSE:

Heavier, stronger, more fireproof. Blows without flash or violence. Metal parts won't corrode and stick. Easier to renew.

'UNION' RENEWABLE FUSES

The "Union" saves more than ANY other renewable fuse. Write for catalog.

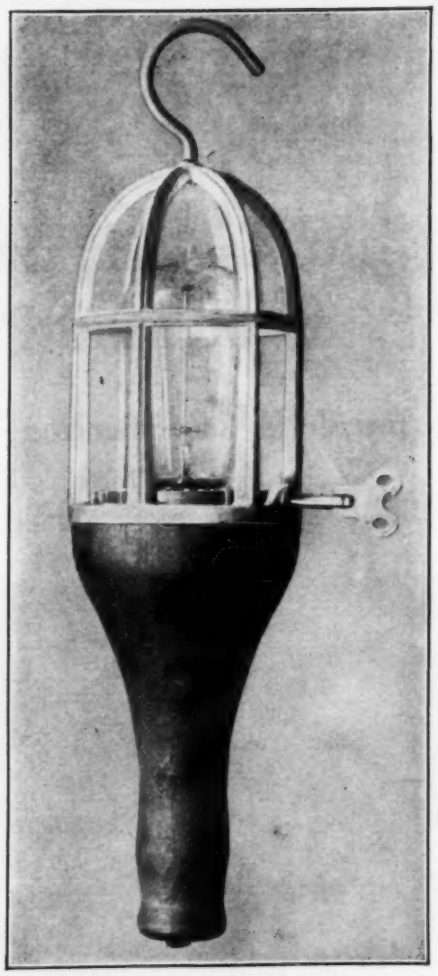
CHICAGO FUSE MFG. CO.

Manufacturers also of Switch and Outlet Boxes, Cut-out Bases, Fuse Plugs, Fuse Wire and Automobile Fuses.

CHICAGO **NEW YORK**

Porto Guards

for Portable Hand Lamps



Patented September 2, 1919

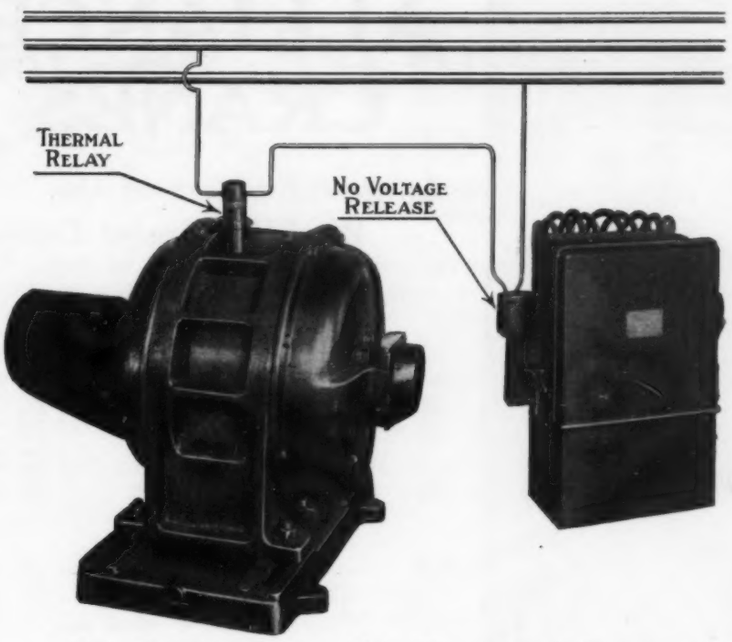
1—Reduce cost of maintenance.
2—Solid casting of great strength.
3—Key locked to prevent loss of lamps.
4—Light in weight.
5—Cable connections made in handle—no strain on socket leads.
6—Sockets are entirely enclosed in handle.
7—Proven efficiency through 5 years' service.

No. 2	**60 Watt Lamps Light**
No. 1	**60 Watt Lamps Heavy**
No. 1A	**150 Watt Lamps Heavy**

Write for descriptive circular.

W. F. HESSEL COMPANY

114 Liberty Street **New York**



Motor Protection Based on Motor Temperature Is Correct

How to Reduce Rewinding of Motors

YOU do not want to shut a motor down, even though it is running single phase or overloaded, until it is absolutely necessary to do so.

A TIME comes, however, when the motor must either be shut down or allowed to roast out.

MOST motors have to be rewound because they have roasted out.

ROASTING out of a motor may be due to "single-phasing," overload, rotor dragging on stator, or other causes.

WHATEVER the cause, the motor overheats.

IT is this overheating that does the damage and dictates when the motor must be shut down to avoid a breakdown.

That is why you should install a simple, effective, reliable, and inexpensive type "TR" Thermal Relay on each of your motors.

Bulletin 402-F Gives Details.

THE AUTOMATIC RECLOSING CIRCUIT BREAKER CO.

COLUMBUS, OHIO

PITTSBURGH: 223 Oliver Bldg.
ST. LOUIS: 401 National Bank of Commerce Bldg.
WILKES-BARRE, PA.: 816 Miners Bank Bldg.
CHARLESTON, W. VA.: 317-318 Moore Bldg.

ALLIANCE CRANES

Largest Builders of the World's Largest Cranes

204 of 100 Tons Capacity and Over

STANDARD CRANES

55	100	tons
2	115	tons
42	125	tons
24	150	tons
22	175	tons
2	200	tons
1	225	tons
1	250	tons
3	430	tons

STRIPPING CRANES

8	100	tons
1	125	tons
19	150	tons
13	200	tons
1	Single Ram, 320	tons

COMBINATION CHARGERS AND STRIPPERS

3	100	tons
3	150	tons
4	200	tons

Pittsburgh Transformer Company

Largest Manufacturers of Transformers Exclusively in the United States

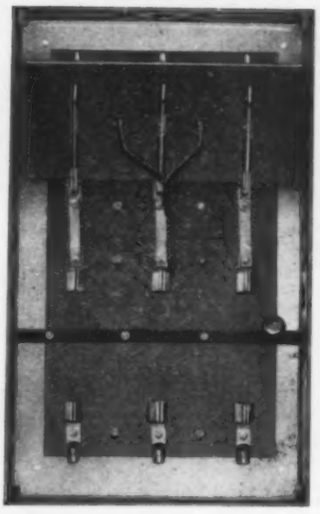
Pittsburgh, Pennsylvania

Wayman

SAFETEE SWITCH

Made Especially for Industrial Control Work

Made in Voltages 125 to 600—in Ampere Capacities 30 to 1200—Fused or Unfused



Its simplicity and correctness of design—quality of material and construction not only insure freedom from service troubles, but eliminates all possibility of personal injury from shock.

Live parts cannot be touched when door is open—Door cannot be opened when switch is closed—Switch cannot be closed when door is open, while the positive quick make and quick break features must work with the movement of operating handle.

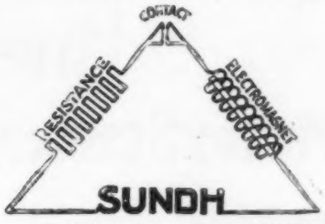
These with many other features of effectiveness and durability distinctively WAYMAN in character make it the most accurate and desirable switch for industrial use.

A recent folder on Safetee Switches illustrates and describes its many new features—Where shall we send your copy?

The Wayman Electric & Mfg. Company

East Palestine, Ohio

The Elements of our Business



	Bulletin
Alarm, High and Low Liquid Level	3610-3615
Automatic Fire Pump Panels, Combined Hand and (See Panels, Fire Pump).	
Automatic Starters (See Starters, Automatic).	
Automatic Transfer Switches	5800
Brakes, Magnetic	9920
Circuit Breakers	3800-3815
Contactors (See Switches, Magnet).	
Control, Machine Tool	9000
Controllers, Elevator	9999
Elevator Controllers	9999
Fire Pump Panels (See Panels, Fire Pump).	
Float Switches	3600-3625
Hand and Automatic Fire Pump Panels, Combined. (See Panels, Fire Pump).	
Hand Operated Switches	3600
Hand Starters (See Starters, Hand).	
High and Low Liquid Level Alarm Switches	3610-3615
Indicator, Level, Liquid, Remote	3625
Level, High and Low Liquid, Alarm Switch	3610-3615
Level, Indicator, Remote	3625
Lighting Panels, Remote Control	7100
Low Levels, High and, Alarm Switches	3610-3615
Machine Tool Control	9000
Magnetic Brakes (See Brakes, Magnetic).	
Magnet Operated Valves	5700
Magnet Switches, A. C.	7600
Magnet Switches, D. C.	7500
Magnets	6500
Manual Fire Pump Panels (See Panels, Fire Pump).	
Manual Starters (See Starters, Hand).	
Panels, Fire Pump	8800-8830
Panels, Lighting, Remote Control	7100
Panels, Pressure Regulator (See Pressure Regulator, also Panels, Special.	
Panels, Special	5400-5423
Pressure Regulator, Gauge Type	4900-4902
Pressure Regulator Panels (See Panels, Special).	
Regulator, Pressure (See Pressure Regulator).	
Regulators, Speed (See Speed Regulators).	
Relay, Tumbler	7250
Remote Controlled Lighting Panels	7100
Remote Controlled Speed Regulators (See Speed Regulators).	
Remote Liquid Level Indicator	3625
Remote Switches (See Switches, Remote, also Switches, Magnet).	
Self Starters (See Starters, Automatic).	
Solenoids (See Magnets).	
Solenoid Operated Valves	5700
Special Panels (See Panels, Special).	
Speed Regulators, D. C.	8500-8520
Starters, Automatic, A. C.	5800-6200
Starters, Automatic, D. C.	5300-5350
Starters, Hand	8320
Starters, Hand, D. C.	8200
Starters, Manual (See Starters, Hand).	
Sump Switches (See Switches, Float).	
Switches, Float	3600-3625
Switches, Hand Operated	3600
Switches, High and Low Liquid Level Alarm	3610-3615
Switches, Magnet, A. C.	7600
Switches, Magnet, D. C.	7500
Switches, Remote (See also Switches, Magnet)	7200-7250
Switches, Sump (See Switches, Float).	
Switches, Tank (See Switches Float).	
Switches, Time	6900
Switches, Transfer, Automatic	5600
Tank Switches (See Switches, Float).	
Terms	300
Time Switches	6900
Transfer Switches, Automatic	5600
Tumbler Relay	7250
Valve Control	5700
Valve, Magnet Operated	5700
Valve, Remote Controlled	5700

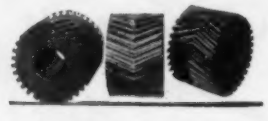
WRITE FOR CATALOG

SUNDH ELECTRIC COMPANY, NEWARK, N. J.

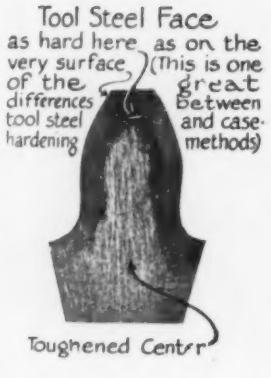
Herringbone Mill Pinions

Motor and Crane Gears

Mill Table Gears

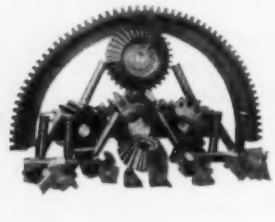


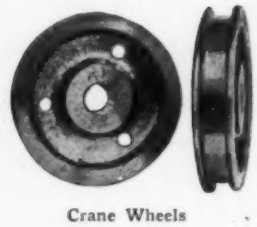
Herringbone Gears


Tool Steel Face
as hard here as on the very surface (This is one of the great differences between tool steel and case-hardening methods)
Toughened Centre

Cincinnati "Tool Steel" gears outlast 8 to 10 Untreated and are much stronger

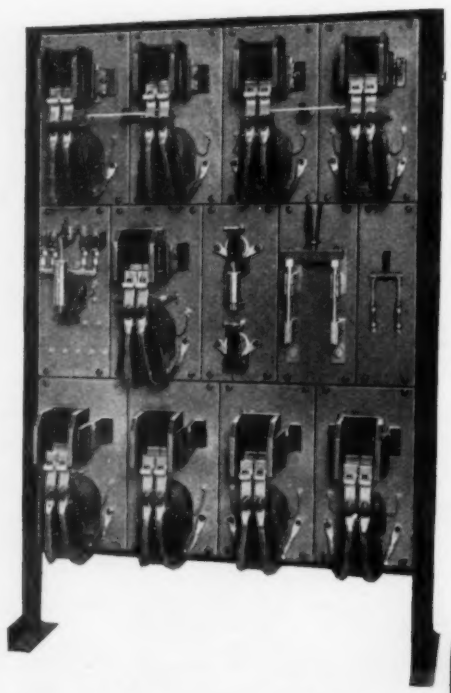
Coupling Boxes and Spindles





Crane Wheels

The Tool Steel Gear and Pinion Company
CINCINNATI, OHIO



150 H.P. Type 4750 Full Speed Reversing Mill Controller

Automatic Motor Starters and Controllers
FOR
Alternating and Direct Current Electric Motors

May we send our nearest representative to see you?

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

CORLISS NJC

for

Rotary Collector Rings

—less dusting
—less cutting
—longer life

CORLISS CARBON COMPANY
BRADFORD, PA.

Pittsburgh,
Union Arcade

(Do you receive our monthly bulletin?)

New York,
90 West Street

SAND—is the only cure for *slippery crane runways*

"IT TAKES SAND TO WIN"

Do you allow your men to pour it on with a bucket?——

Or do you allow your cranes to be operated on slippery runways?

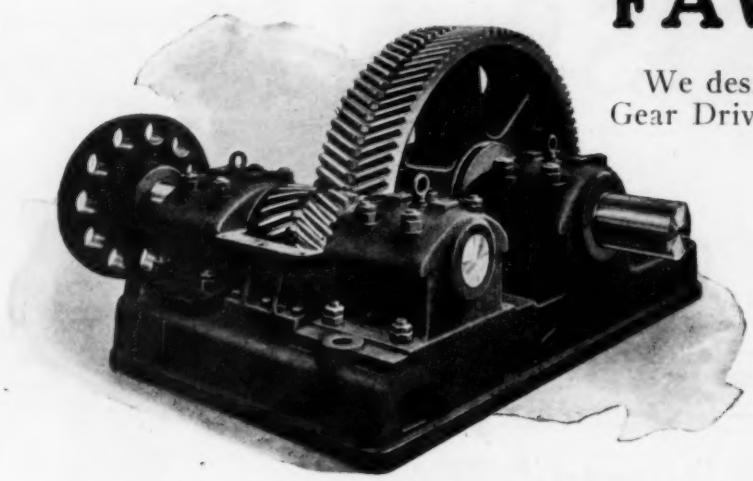
Both methods endanger your cranes, the lives of your operators and the men on the floor.—This also means unnecessary delays and losses.

Apply sand at the right time, the right place and in the proper amount by equipping your cranes with Lintern Electro Magnetic Sanders.

A number of plants are now in the process of equipping all of their cranes with Sanders. They will secure efficient and economical operation with all hazards due to slippery rails eliminated.

THE NICHOLS-LINTERN COMPANY
7960 Lorain Avenue **Cleveland, Ohio**

FAWCUS HERRINGBONE GEAR DRIVES



FAWCUS HERRINGBONE GEAR DRIVE

We design and build enclosed Herringbone Gear Drives for transmitting maximum loads up to and including 15,000 horsepower for mills of all kinds.

We are well equipped both in engineering ability and manufacturing facilities to handle the unusual as well as the standard mill drive propositions.

Fawcus drives will effect large savings in power consumption, wear, tear and maintenance costs.

FAWCUS MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

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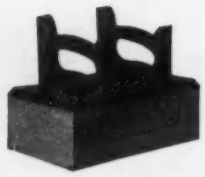
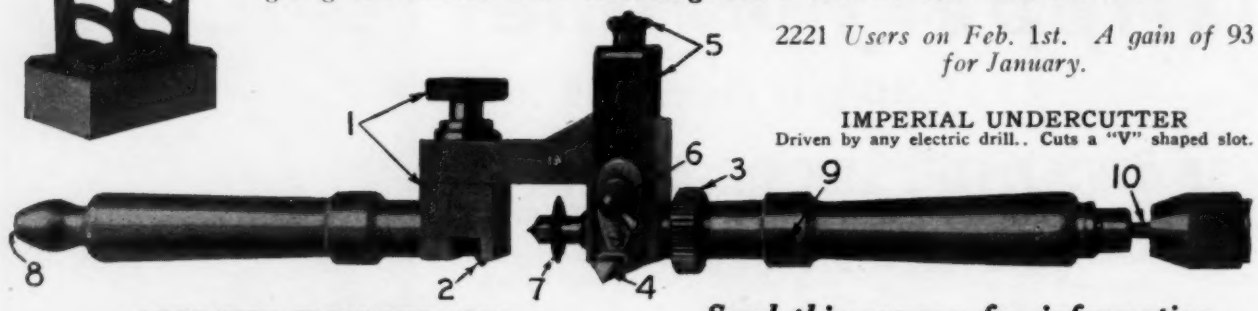
Use "Imperial" Commutator Stones

1. They Will Not Foul with Copper.

The careful mixing, molding and baking of Imperial Stones insures a clean, fast-cutting surface with no hard spots to collect copper. Write for bulletin giving full information. **Advantage No. 2 Will Be Given Next Month**



2221 Users on Feb. 1st. A gain of 93 for January.



IMPERIAL UNDERCUTTER
Driven by any electric drill.. Cuts a "V" shaped slot.

GOODNITE CLEANING TOOL
For cleaning Commutator slots

COMMUTATOR SLOTTING FILES
For undercutting mica

We can supply you with

Commutator Grinders	Insulating Beads
Slotting Machines	Insulating Varnish
Commutator Cement	Gauze Wire Brushes
Portable Blowers	

Send this coupon for information.

THE MARTINDALE ELECTRIC CO.,
11729 Detroit Ave., Cleveland, Ohio.

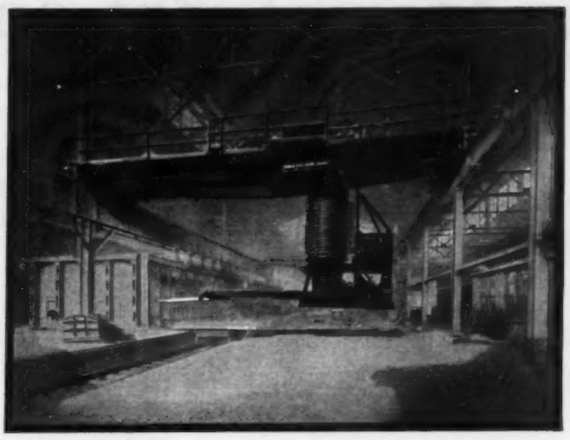
Gentlemen: Please send me information about your products.

Name and Title .....
(Please print)

Company .....

Street .....

City and State .....



Morgan 5-Ton, 45′-0″ Span Overhead Revolving Type Billet Charger

The World's Standard

Morgan Equipment has won the title, "The World's Standard," because it measures up so fully to the heavy, exacting demands of the steel industry.

Morgan Equipment has been so closely allied with the steel industry for so many years that it just naturally seems to be a part of it.

You'll find Morgan Equipment profitably busy in most every steel plant.

The Morgan Engineering Company

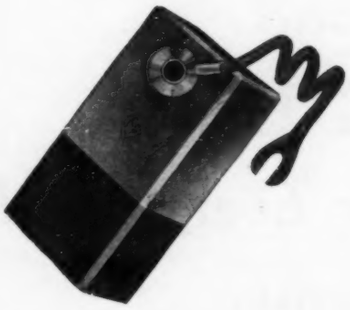
CHICAGO
122 So. Michigan Ave.
NEW YORK
120 Broadway
PITTSBURGH
1420 Oliver Bldg.

ALLIANCE, OHIO

Designers, Manufacturers and Contractors

Electric Traveling Cranes, Rolling Mill Machinery, Ordnance Steel, Shipbuilding and Forging Plants Complete, Rock Crushers, Special Machinery for Any Purpose

Locomotive Repairing and Rebuilding



We Know What You Want

U. S. G. Brush engineers have made a study of the requirements of steel mills and are in a position to recommend and furnish carbon, graphite or metal brushes for that service which are absolutely guaranteed to be satisfactory.

If your machines are not yet equipped with U. S. G. brushes it will be to your advantage to write for Catalog B-3—really a text book on brushes.

USG

on every brush

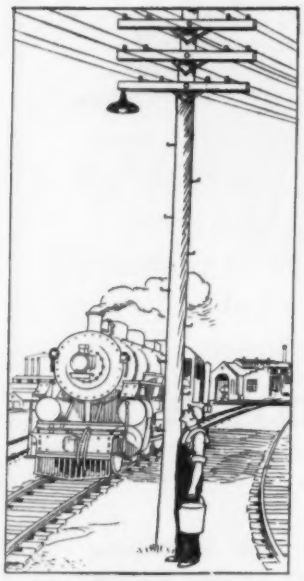
The United States Graphite Company

Main Office and Factory

Saginaw, Michigan, U. S. A.

BRANCHES: New York Pittsburgh St. Louis Denver Philadelphia Chicago San Francisco

Not only **Safety** but **More Light** and **Longer Life** of the Reflector



Difficult and Dangerous

Even if he did climb up, he could not hold the reflector so as to do a good job of cleaning.

DIRTY REFLECTORS DO NOT REFLECT

The greatest problem in reflector-cleaning is how to get at it.

THOMPSON

Safety DISCONNECTING Hangers

—enable high lamps to be lowered away from the electric circuit for cleaning and renewals.

The Hanger is as necessary to the reflector as the reflector is necessary to the bulb.

The reflector 'costs' more than the bulb and does not 'produce' any light; that is done only by the bulb—and only a 'clean' reflector 'saves' light.

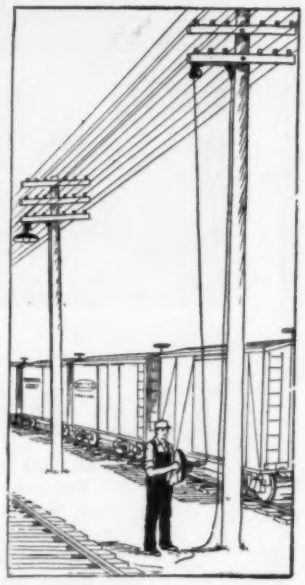
Consider what the reflector-cleaner has to do to get at the high lamps.

Why lose the benefit of your reflector investment for want of adequate facilities for keeping them clean?

Get Catalog B-21 for details.

The Thompson Electric Company

226 St. Clair Ave., N. E.
CLEVELAND, OHIO, U. S. A.



Easy and Safe

Why not add enough to the equipment to make it workable.

There is a

HOLOPHANE LIGHTING UNIT

for Your Every Need

The Unit illustrated is especially recommended for industrial plants

RUMSEY
ELECTRIC COMPANY
Electric Supplies and Machinery
Everything in Radio
1007 Arch St.
Philadelphia, Pa.

A Selection that insures satisfaction

There's a Moloney Transformer of a type and size for all central stations and industrial requirements. This company has spent nearly thirty years in the development and manufacture of transformers. Specify Moloney Transformers—they insure perfect satisfaction.

Ask for complete data

Moloney Electric Company

Main Office and Factories

St. Louis, Mo.

Sales offices in Principal Cities

Moloney Transformers

Buckree

In the Kumaon country they use buckrees to carry freight.

"Why do they use goats?" ventures the traveler. "They carry such small loads that it must take a long time to complete a hauling job."

The native explanation is, "What is time to a goat, anyway?"

And so it is with the excuses men give for using cheap guess-picked brushes.

—"What is wear to a brush?"

—"What is time to a commutator?"

—"What is money to the boss?"

"Nothing," we answer, and we turn our engineering services to **prescribing** proper Morganite types for the **thinking** men who want to **save money** on brushes, commutators and service.

MORGANITE BRUSH CO., INC.
519 West 38th St., New York City
DISTRICT ENGINEERS AND AGENTS

Morganite

Electric Power Equipment Corp., 412-420 North 18th St., Philadelphia, Pa.

O. T. Hall, Sales Engineer, 1926 Edmondson Ave., Baltimore, Md.

Electrical Engineering & Mfg. Co., 909 Penn Ave., Pittsburgh, Pa.

Electrical Engineering & Mfg. Co., 422 Union Bldg., Cleveland, Ohio.

Special Service Sales Co., 502 Delta Bldg., Los Angeles, Calif.

Special Service Sales Co., 202 Russ Bldg., San Francisco, Calif.

J. F. Drummey, 75 Pleasant St., Revere, Mass.

Electrical Engineering & Mfg. Co., 607 Mercantile Library Bldg., Cincinnati, Ohio.

Railway & Power Engineering Corp., Ltd., 131 Eastern Ave., Toronto, Ontario, Canada.

LAPP HIGH VOLTAGE PORCELAIN

Did you ever hear of a failure of a Lapp Insulator?

Seven years of production—including highest voltage pin and suspension types —without a failure!

There is the reason for use of Lapp Insulators, besides which—for "trimmings" —they provide unexcelled mechanical strength.

Lapp vacuum process of porcelain production, surfaces of porcelain glazed all over, Lapp over potential test methods.

LAPP INSULATOR CO., Inc., LeRoy, N. Y.

S. H. LANYON
509 New Call Bldg., San Francisco

O. H. Davidson Equipment Co.
1633 Tremont St., Denver

Commercial Electrical Supply Co.
Broadway and Spruce St., St. Louis

J. E. Sumpter Co.
940 Security Bldg., Minneapolis

F. R. Jennings Co.
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Robertson-Cataract Electric Co.
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J. W. Fraser & Co.
Charlotte, N. C.

Rumsey Electric Co.
1007 Arch St., Philadelphia

Shield Electric Co.
149 Broadway, New York City

W. D. Hamer Co.
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Union Electric Co.
933 Liberty Ave., Pittsburgh

Wetmore-Savage Co.
76 Pearl St., Boston

Jas. J. Niven & Co.
Wellington, New Zealand

The A. I. & S. E. E. Iron and Steel Cost and Practice Chart

Mr. Barton R. Shover, Consulting Engineer of Pittsburgh, Pa., has prepared the chart which is enclosed with this March Issue of Iron and Steel Engineer.

Non-members desiring a copy may secure one by writing to Association of Iron and Steel Electrical Engineers, 708 Empire Bldg., Pittsburgh, Pa.

The price of the chart is $3.00.

"LE CARBONE" CARBON BRUSHES

Standard of Quality and Uniformity

They are supplied not alone to suit type of machine, but your operating conditions.

Guaranteed Without Argument.

Real Engineering Service.

W. J. Jeandron, 345 Madison Ave., New York

Pittsburgh Office, 634 Wabash Bldg.
W. P. POYNTON, Electrical Engineer

San Francisco Office, 525 Market St.
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Canadian Distributors: Lyman Tube & Supply Co., Ltd.
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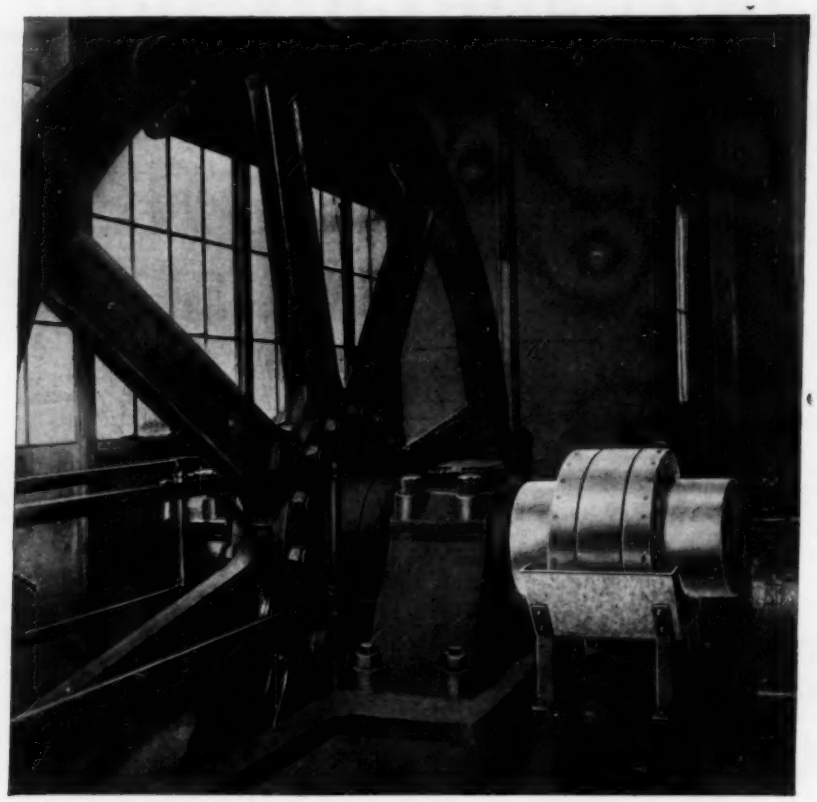


Nine years on a 16" mill is a pretty good test of whether a flexible coupling is serviceable and durable. This size No. 33 double type **Francke** flexible coupling has stood that test and it is good for many more years of service.

All such double type **Franckes** should be operated in suitable enclosing oil cases. Simply add a small amount of oil every week or two and the coupling is self-lubricating.

There are several distinct types of **Francke** flexible couplings for drives from ¼ H.P. to 5,000 H.P. described in Bulletin No. 37, which we will send you on request.

SMITH & SERRELL

Coupling Specialists Since 1912.

47 Central Avenue, Newark, N. J.

District Office, Fulton Building, Pittsburgh

FRANCKE
FLEXIBLE COUPLINGS

"They make good machines last longer"

Fig. 1.

Fig. 2.

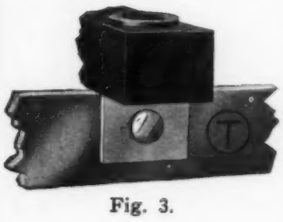


Fig. 3.

Fig. 4.

Iron and Steel Electrical Engineers:

You Iron and Steel Engineers represent probably the first body of men who individually and collectively appreciated that to obtain safety in switches something far more was necessary than just a safety box.

No body of men know better than you the unfortunate position in which safety switches have been placed because of a long drawn propaganda by salesmen and press eulogizing the safety box which keeps the operator away from the live parts of the switch. Such propaganda paid no attention whatever to the first necessity of safety in switches—namely the type of switch in the box that is to do the work.

From the beginning until now, there are few manufacturers and fewer contractors and engineers who pay enough attention to the construction of the knife switch proper, thinking as they do that safety switches mean a safety box surrounding most any kind of a switch.

Even the Underwriters in classifying safety switches speak of Class A, Class B, Class C or even Class AA in terms of boxes only—disregarding the switch entirely—an A box may contain the cheapest switch imaginable. One safe switch for industrial use is the Trumbull Type A manufactured for nearly twenty-five years. The Trumbull type A switch is machine made—built-up, most rigidly constructed and **quick-make** and **quick-break.** It will stand up under use and abuse.

The Illustrations Show

Figure 1—Foot-block and the pin that fastens the blades to the foot-block after it has been sweated.

Figure 2—Shows contact jaw complete.

Figure 3—Shows method of fastening the blade to the fibre cross-bar, making a unit of the blade and crossbar.

Figure 4—Shows long and strong quick make quick break spring that at no time is worked more than 50 per cent of its capacity.

The Trumbull Electric Mfg. Company

114 Liberty St., New York City
535 Mission St., San Francisco, Cal.

Plainville, Conn.

2001 W. Pershing Rd., Chicago, Ill.
Boston Philadelphia Atlanta

BUILT LIKE SANGAMO A WATCH

Every point in the design and construction of SANGAMO METERS has been carefully worked out with a view to these considerations:

1. Sustained Accuracy.
2. Reliability and Sturdiness.
3. Low Cost of Maintenance.

Wherever electric energy is measured accurately—you will find a SANGAMO Product made expressly for the purpose.

SANGAMO PRODUCTS INCLUDE:

D. C. Watthour Meter, Type D-5
Switchboard Tpye
Service Type
Portable Test Outfits

A. C. Watthour Meters, Type H,
Single phase and Polyphase
Switchboard Type
Service Type
Maximum Demand Meters
Rotating Standards

Amperehour Meters
Switchboard Type
Locomotive Type
Service Type

Current and Potential Transformers

LUDWIG HOMMEL & CO.

LUDWIG HOMMEL & CO.

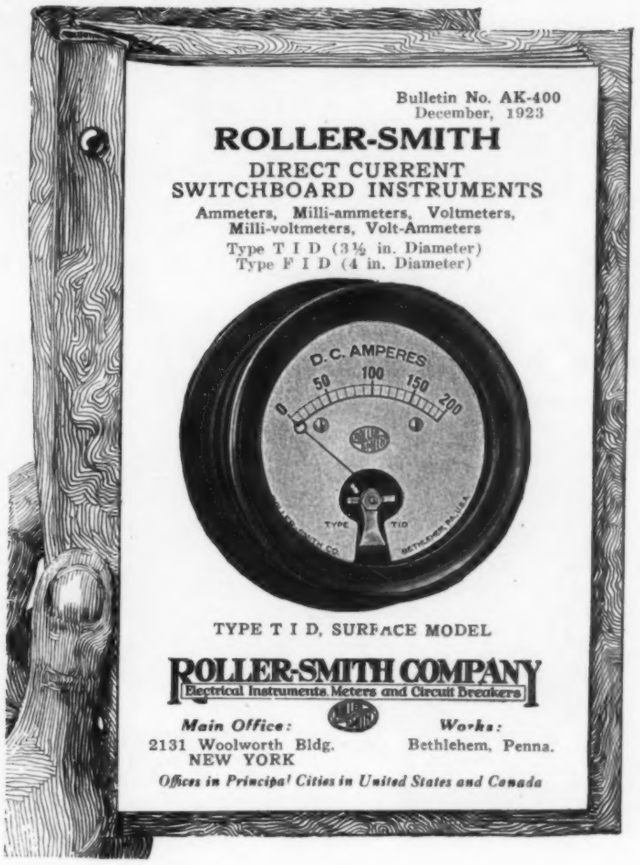
530 Fernando St.
PITTSBURGH, PA.

Rose Building
CLEVELAND, O.

Pittsburgh District Managers: Wagner Elec. Corporation
Sales Representatives
Sangamo Elec. Co.

NEW!

An addition to the Roller-Smith Bulletin file—just off the press—full of data on the application of small instruments to such work as battery charging outfits, farm lighting plants, signal systems, X-Ray, Radio and for small panels of ALL kinds.



For your convenience

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Request for Roller-Smith Bulletin AK-400

Name .....

Company .....

Address .....

City ..... State .....

AIR or OIL?

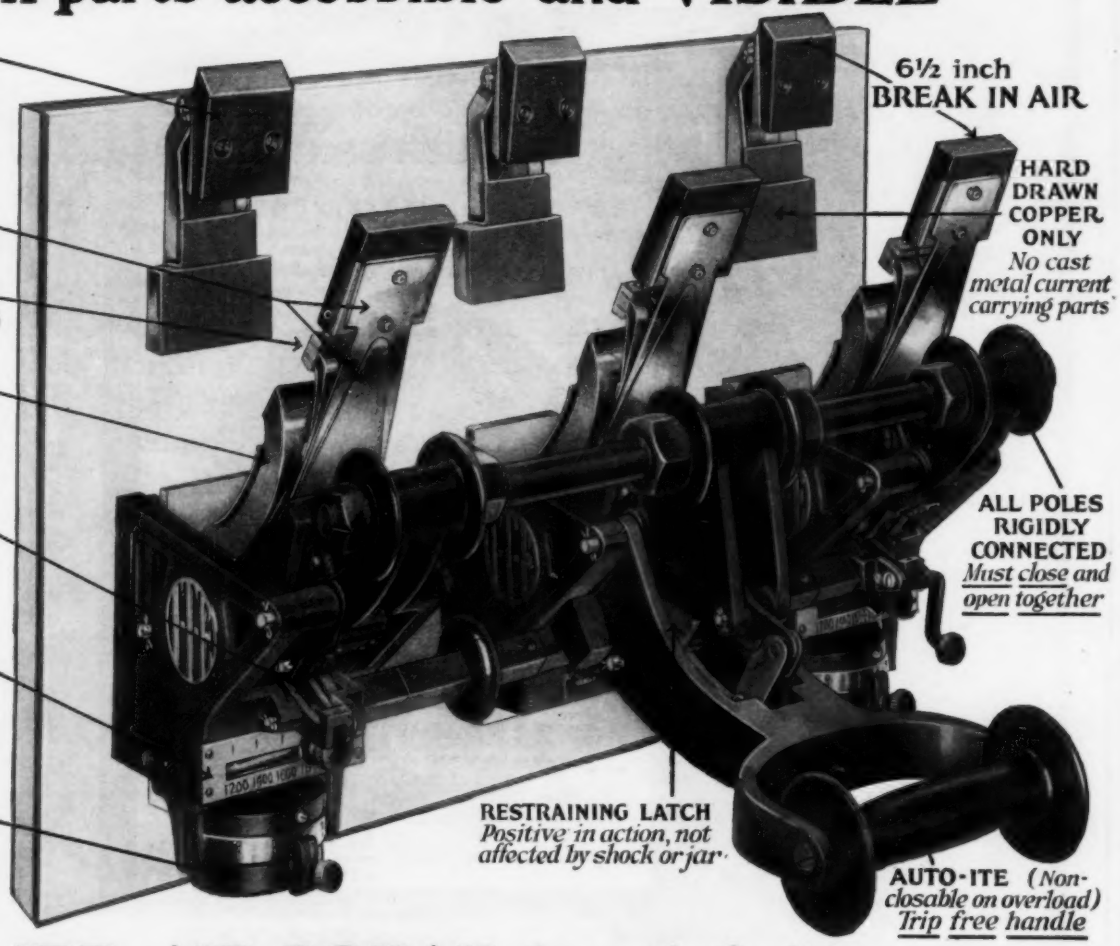
CIRCUIT BREAKERS

For Alternating Current

600 VOLTS OR LESS

Give protection without complication

All parts accessible and VISIBLE


COPPER JACKETED PRESSURE CARBONS
For initial contact and final break
Mechanically strong
Electrically perfect
PHOSPHOR BRONZE CARBON SUPPORTS
HEAVY METALLIC SECONDARY BREAKING CONTACTS
LAMINATED BRIDGE
Each leaf individually formed - Heavy even pressure on every Lamination
CLOSING TOGGLES
Afford heavy contact pressure with easy closing
OVERLOAD
Direct acting. Long scale calibration. No relays or series transformers
DALITE
(Direct acting time limit) feature. Adjustable from zero to maximum time. No relays
6½ inch BREAK IN AIR
HARD DRAWN COPPER ONLY
No cast metal current carrying parts
ALL POLES RIGIDLY CONNECTED
Must close and open together
RESTRAINING LATCH
Positive in action, not affected by shock or jar
AUTO-ITE (Non-closable on overload)
Trip free handle

I-T-E AIR BREAK has definite advantages not present in the oil breaker

1. *No oil — to leak, carbonize, burn or explode — Just air.*
2. *No tanks to conceal anything — or the lack of it.*
3. *No cells — nothing which needs or deserves to be imprisoned — Just a faithful and efficient servant.*
4. *Inherent simplicity — with resulting low cost of installation and maintenance.*

The I-T-E CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA

Galvanizing Take-up Frame driven by 50-h.p., 850-r.p.m. Type T Reliance Motor. A 10:1 speed variation is obtained in the motor, giving a minimum speed of 85 r.p.m.

The steel man's wants constantly in mind

Every step in the design and manufacture of Type T motors is influenced by the needs of steel mill service.

We know from intimate contact with steel mill work the great need for quality and strength in every part. Eight years of service on all kinds of tough jobs have demonstrated that Type T motors are built to stand hard usage and to stand it longer than the ordinary motor.

We know also that in addition to quality, the steel mill electrical engineer is interested in the stability of motor design. Recognizing this, no change has been made in eight years that affects the interchangeability of Type T motors.

Our Bulletin 2014 contains 77 illustrations showing how Type T Reliance Motors are made and how they have been applied to a variety of work. We shall be glad to send it.

The feet of Type T Reliance Motors are cast integral with the steel frame. Wide ribs carried up from the feet give the most effective support. The bottoms of the feet are machined. The base holes are jig drilled and seats for holding-down bolts are spot faced. Special attention is given to the accuracy of those dimensions affecting the direct connection of the motor to a machine.

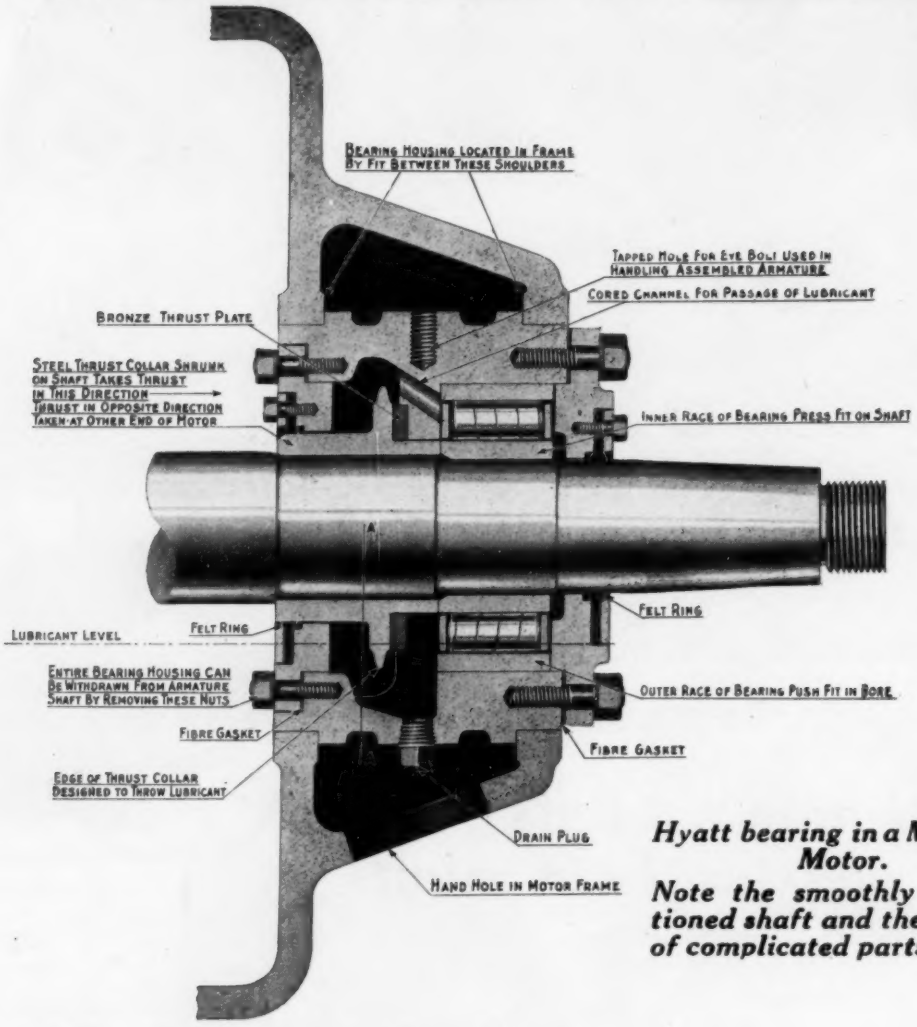
Reliance Electric & Engineering Company

1080 Ivanhoe Road, Cleveland, O.

Branches: Boston, New York, Philadelphia, Pittsburgh, Cincinnati, Detroit, Chicago

Type T Heavy Duty RELIANCE MOTORS Direct Current

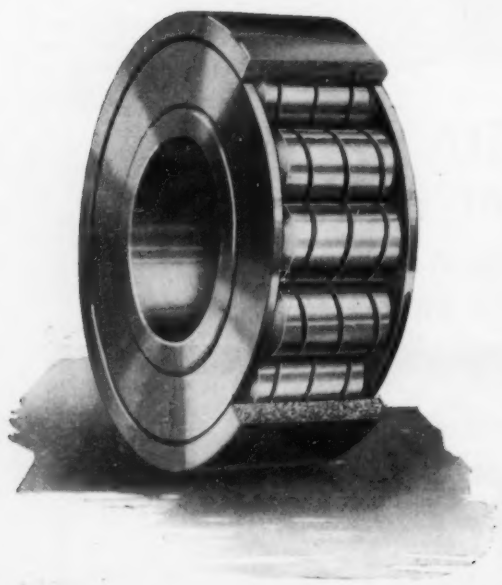
HYATT ROLLER BEARINGS FOR ELECTRIC MOTORS


BEARING HOUSING LOCATED IN FRAME BY FIT BETWEEN THESE SHOULDERS
TAPPED HOLE FOR EYE BOLT USED IN HANDLING ASSEMBLED ARMATURE
CORED CHANNEL FOR PASSAGE OF LUBRICANT
BRONZE THRUST PLATE
STEEL THRUST COLLAR SHRUNK ON SHAFT TAKES THRUST IN THIS DIRECTION
THRUST IN OPPOSITE DIRECTION TAKEN AT OTHER END OF MOTOR
INNER RACE OF BEARING PRESS FIT ON SHAFT
FELT RING
LUBRICANT LEVEL
FELT RING
ENTIRE BEARING HOUSING CAN BE WITHDRAWN FROM ARMATURE SHAFT BY REMOVING THESE NUTS
OUTER RACE OF BEARING PUSH FIT IN BORE
FIBRE GASKET
FIBRE GASKET
EDGE OF THRUST COLLAR DESIGNED TO THROW LUBRICANT
DRAIN PLUG
HAND HOLE IN MOTOR FRAME

Hyatt bearing in a Mill Type Motor.

Note the smoothly proportioned shaft and the absence of complicated parts.

This Series of Bearings Was Designed for Electric Motor Service



Each size bearing has sufficient capacity to carry the load of its respective motor without demanding an increase in existing shaft sizes—there is no awkward enlargement of the shaft for the sake of bearing capacity.

No lock nuts, threads or other devices are required to mount the bearing—shaft fatigue and breakage are reduced.

The housing required is small enough in diameter to prevent interference with ventilation.

Self lubricating, shock-proof and durable, the Hyatt roller bearing is the simplest solution of the bearing problem in electric motors.

HYATT ROLLER BEARING COMPANY
NEWARK, N. J.

The book that puts your 5 foot shelf out of date

With the new Western Electric Year Book on your desk you have finger-tip information on over 60,000 electrical items —a veritable five-foot shelf of books, condensed and indexed for your convenience.

The completeness of Western Electric stocks means a real convenience in buying. Your order for everything electrical can be filled by our nearest Distributing House.

You will find that Distributing House mighty handy, too. It is one of 47 placed at important centers so we can speed up deliveries.

Write for your copy of the Year Book to our nearest House or 100 East 42nd St., New York City.

Western Electric Company

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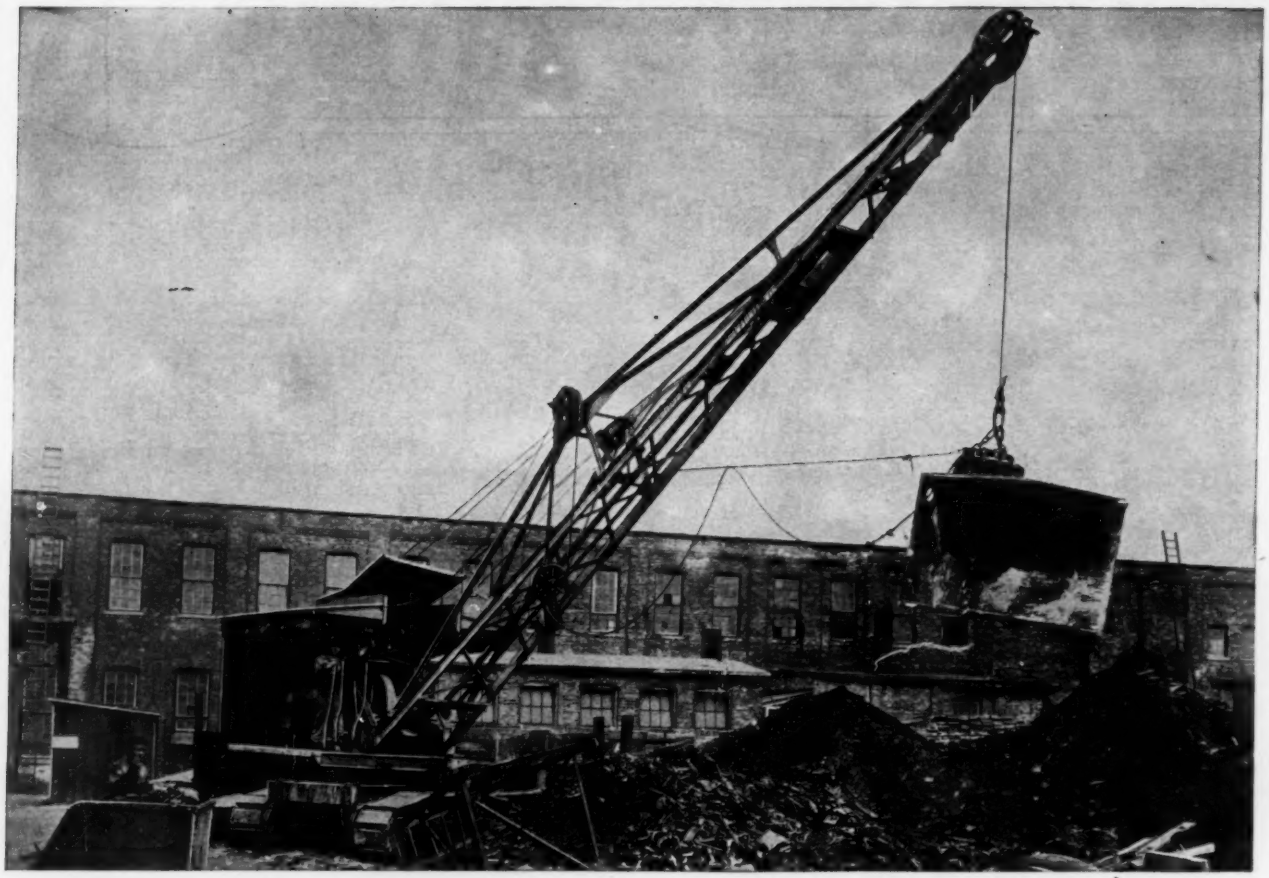

P & H 206 Corduroy Crane Handling Scrap with Lifting Magnet in yards of American Manganese Steel Co.

One Man Operated, Gasoline or Electric Power

No Tracks Required—Economy

The P & H Corduroy Crane is a valuable all-around full-revolving handling crane for steel plant use. It is easily maneuvered anywhere on its Corduroy Traction—is ready for work at a moment's notice—requires no attention or use of fuel except when doing actual work—and is entirely handled by one man. You can readily appreciate the versatility and economy of this machine.

The quality of design and construction of this Crane is on a par with P & H Overhead Traveling Cranes and Hoists, insuring long service with minimum maintenance cost.

You can use this same machine with magnet; clamshell bucket for handling of coal, ash, gravel, etc.; with chain slings; or with a drag-line bucket.

CORDUROY

Follow the Corduroy Trail --the "Tread" Mark of the P & H

Among the prominent plants using P & H Corduroy Cranes are:

Aluminum Company of America, American Brass Co., American Manganese Steel Co., American Radiator Co., American Steel & Wire Co., The Bettendorf Co., Canadian Pacific Railway Co., The Ingalls Iron Works Co., Malden & Melrose Gas Light Co., Standard Oil Co., Standard Sanitary Mfg. Co., Sullivan Machinery Co., Western Pipe & Steel Co.

Bulletin 40-X will help you visualize the economy of P & H Corduroy Cranes for your yards—Make a memo to have us forward a copy today.

PAWLING & HARNISCHFEGER CO.

Established in 1884

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New York Phoenix San Francisco Birmingham Chicago
Salt Lake City Pittsburgh Dallas St. Louis
Portland Denver Philadelphia Atlanta
Memphis Seattle Los Angeles Kansas City

P&H CORDUROY CRANES

The REAL STANDARD "UNIT TYPE"

THERE ARE OVER
7,000
UNIT TYPE BUS
SUPPORT
COMBINATIONS

Next Time You Need

high tension Bus Supports, specify UNIT TYPE and you will have made the best buy in the market. UNIT TYPE design was not an accident—it is a real idea.

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Delta-Star Electric Co

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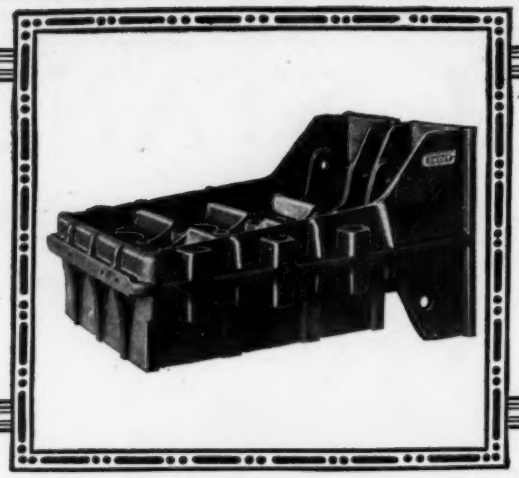


Rigid structure for supporting the mechanism and insulation — the foundation of the breaker.

Massive Rigid Frame

IN judging any structure, the first question usually considered is the stability of the foundation. The frame is the foundation of an oil circuit breaker — it carries the mechanism — it supports the insulators with the contacts and in the CONDIT design its deep web flange reinforces the tank against the dangerous "over-the-oil" explosion.

Rigidity in the frame assures stability, proper functioning of the mechanism, positive contact alignment on all poles, and strength to resist unbalanced stress and strain. In other words, the ability of an oil circuit breaker to function properly depends, after all — more on the rigidity than strength of the frame.

CONDIT frames afford a maximum factor of structural safety consistent with the duty involved. For dependability, build your system on a solid foundation, for in the last analysis — a breaker is no better than the rigidity of its frame.

Write for our catalog.

Get in touch with Condit

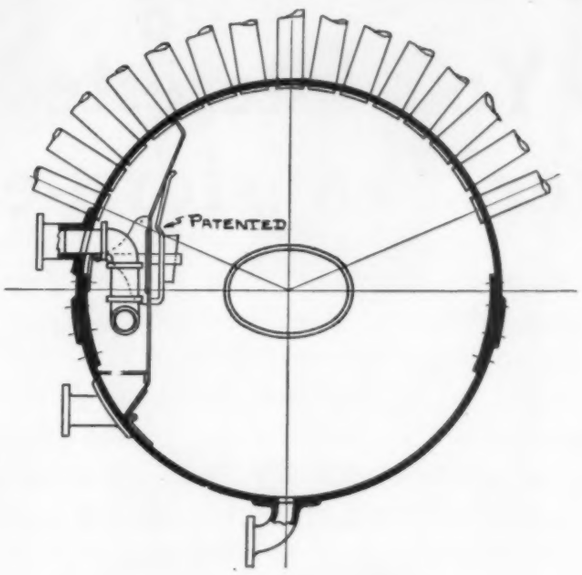
CONDIT ELECTRICAL MFG. CO.
Manufacturers of Electrical Protective Devices
South Boston, Mass.

Northern Electric Company LIMITED
Sole Distributor for the Dominion of Canada

CONDIT
Features

1. "Double" tanks.
2. Energy Absorption.
3. Self-contained mufflers.
4. Massive rigid frames.
5. Laminated contacts.
6. Truck type units.

CONDIT



LADD
WATER TUBE BOILERS

The LADD patented feed box arrangement is one of many practical exclusive features of the LADD design. It's use permits the feed water to be brought to boiler temperature before getting to the active circulation of the boiler.

The advantages of this arrangement may be summarized as follows:

1. Boiler can be operated for longer periods between cleaning than other types as the insoluble elements are deposited in the rear section and blown off.
2. There is a distinct saving in fuel,—as a large percentage of the hot water does not have to be blown down to keep the concentration below dangerous levels.
3. High overloads can be carried and sudden changes in load made without damage to the tubes. In the Ford boilers at 400% rating one feed water has been admitted at 40° F. without the distortion of a single tube.

These and other features are fully described in bulletin No. 22. Write for your copy.

THE GEORGE T. LADD COMPANY

First National Bank Bldg., PITTSBURGH, PA.

CHICAGO OFFICE
528 McCormick Building

NEW YORK OFFICE
39 Cortlandt Street

PHILADELPHIA OFFICE
502 Franklin Bank Building

WATER TUBE BOILER LADD

Are You Interested In Better Transformers?

More than one-third of a century has elapsed since the Packard Electric Company took up the manufacture of transformers. The Packard Brothers at the outset had very definite ideals as to quality of product. Those ideals were implanted into their organization and have been consistently translated into definite accomplishment until today the word "Packard" is a word to conjure with—both in the electrical and auto-motive industry.

Packard Lamps—Packard Automobiles—Packard Automotive Cables and Packard Transformers have all maintained the quality standards established by the Packard Brothers back in 1890.

When you are interested in better transformers it will pay you to get a Packard proposition.

The Packard Electric Company

WARREN OHIO

Transformers for Power, Distribution, Weatherproof Metering and Series Regulating Service

U-RE-LITE

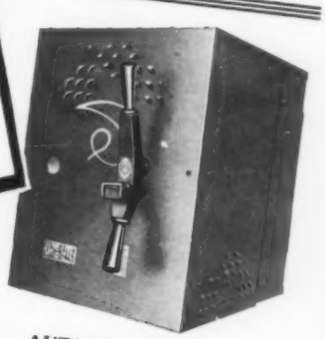
U-RE-LITE Jr. (*250 volts D. C.*)
1 to 60 amps. inclusive.
Features: Overload or overload and Dalite (Direct acting Time limit)

U-RE-LITE Sr. (*250 volts D. C.*)
5 to 200 amps. inclusive
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer.

U-RE-LITE "W" (*250 volts D. C.*)
5 to 400 amps. inclusive.
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer.

U-RE-LITE "NX" (*250 volts D. C.*)
100 to 1250 amps. inclusive.
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer.

AUTO U-RE-LITE Sr.
5 to 150 amps. inc. at 220 volts A. C.
5 to 80 amps. inc. at 550 volts A. C.
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer.



AUTO U-RE-LITE "W"
5 to 400 amps. inc. at 220 volts A. C.
5 to 300 amps. inc. at 550 volts A. C.
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer

AUTO U-RE-LITE Jr.
1 to 60 amps. inc. at 220 volts A. C.
1 to 15 amps. inc. at 550 volts A. C.
Features: Overload - Dalite (Direct acting Time limit.) No voltage or shunt trip. Bell ringer

CIRCUIT BREAKER ENGINEERS To AMERICAN INDUSTRY

The CUTTER COMPANY
ESTABLISHED 1888 ITE PHILADELPHIA

G-E 7000 h.p. (continuous) Reversing Blooming Mill Motor and its Fly Wheel Motor Generator. This is one of two G-E equipments which are the largest electric reversing mill drives ever constructed in this country

Big Tonnage with G-E Motors

Bethlehem Steel Co.—Sparrows Point, Md.

A G-E Motor driving 40″ reversing blooming mill rolled a 23″ x 43″ ingot, 16,500 lb., to a 9″ x 38″ slab in 1 min. 20 sec.; and to an 8″ x 8″ bloom in 2 min. 15 sec. It has rolled 330 tons of 10″ x 40″ slabs in 1 hr., 198 tons of 8″ x 8″ blooms in 1 hr. Has also rolled 50,653 tons of finished product in a month consisting of 26 double turns representing over 60,000 tons of ingots.

Trumbull Steel Co.—Warren, Ohio

A G-E Motor driving 36″ reversing blooming mill rolled a 20″ x 22″ ingot, 6,700 lbs., to a 6¾″ x 6¾″ bloom in 58 sec. requiring 13 passes. Sixty such ingots were rolled to same section in 1 hr., requiring same number of passes. Total number of passes by mill—780, average 4.6 sec. per pass, including time between passes and ingots. During the process of making these 780 passes approximately 15,000 linear feet of metal passed through the rolls.

The manufacturing and engineering facilities of the General Electric Company are unsurpassed. G-E specialists on steel mill electrical equipment are available for co-operative work with steel plant engineers.

Bulletin No. 48031

Every type of electrical device which can find advantageous application in a steel plant fully equipped for electrical operation can be supplied by the General Electric Company. The above Bulletin gives valuable and interesting information about these products and their application to the production of iron and steel. You can secure it upon request.

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